6. SUB-BASIN EVALUATIONS

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To systematically identify specific actions and classes of actions to advance our recovery strategies, we evaluated salmon use and ecological and landscape conditions in 11 distinct sub-basins of Puget Sound to the best of our knowledge synthesizing existing data. Fully evaluating sub-basin specific goals and opportunities will require additional understanding of habitat-species relationships, the complex interactions between multiple populations and multiple species. In these evaluations, we combined the general information presented in Sections 2 through 4 and the hypotheses articulated in Section 5 with geographically specific information on salmon and the landscape in each of the sub-basins to develop recommendations for recovery strategies and actions in each sub-basin. The process of evaluation for each sub-basin included:

- assessment of salmon and bull trout use;
- assessment of ecological and landscape conditions;
- evaluation of realized function for salmon and bull trout (a combination of the capacity of habitats to support fish and the opportunities available for fish to access these habitats);
- identification of fish specific goals; and
- development of recommendations of key protection and improvement actions.

None of these recommendations was coordinated with actions identified in watershed chapters, although some actions identified here are consistent with evaluations done at that scale. These recommendations have been forwarded as suggestions for further review in cooperation with watershed groups, local, state, tribal and federal recovery plans and have not received any policy or feasibility review.

<u>Salmon and Bull Trout Use</u>. Our assessments of Chinook salmon use describe how juvenile, and to a lesser degree subadult and adult, Chinook from the 22 independent populations delineated by the TRT are thought to occur in and use nearshore and marine environments in each of the sub-basins. Where information exists, salmon use by Chinook emanating from outside Puget Sound (e.g., Columbia River) is mentioned. The assessment of use by juvenile Hood Canal/Eastern Strait of Juan de Fuca summer chum and sub-adult and adult bull trout is discussed, but addressed in less detail. These assessments are based on the fish distribution and use hypotheses presented in Section 3 and other available location-specific information. The assessments focus primarily on salmon and bull trout in nearshore ecosystems because we know more about nearshore use than we do offshore habitat use.

<u>Ecological and Landscape Condition</u>. Our assessments of ecological and landscape condition focus on nearshore environments and characterize the current distribution and condition of landscapes, ecological features, and threats and stressors for each sub-basin. We characterized the distribution and condition of the landscape classes and ecological features introduced in Section 2 using information sources identified in Table 6-1 and evaluations of pocket estuaries and drift cells as described in Appendices B and C, respectively.

Evaluation of Sub-basins. The evaluation of each sub-basin includes three main pieces. First, we discuss the level of realized function for each of four life history types of outmigrant juvenile Chinook, outmigrant Hood Canal/Eastern Strait of Juan de Fuca summer chum, and bull trout. Second, we list fish specific goals. Third, we propose recovery actions to protect or improve the conditions that support these various types of fish.

The level of realized function is an aggregate measure of the availability, quality, and quantity of habitats to support salmon consistent with the recovery hypotheses presented in Section 5. Our discussion of realized function is more qualitative than quantitative and allows identification of the features most critical for a given life history strategy or species and the features that support the greatest number of species and life history strategies.

The fish specific goals reflect our and our advisors' professional judgments based on the sub-basin assessments and the evaluation of realized function. Our recommendations of key protection and improvement actions reflect our and our advisors' professional judgments about reasonable approaches to acting on these most critical features.

As recommended by the NOAA-TRT, the material in the 11 sub-basin evaluations is organized and presented to allow the TRT to create recovery scenarios.

Table 6-1: Information Sources for Sub-Basin Assessments

Salmon and Bull Trout Use, Ecosystem Feature, Landscape Class, Stressor or Threat	Source of Information for Sub-Basin Assessment
Juvenile and adult Chinook use, chum use, bull trout use	Technical advisors, NOAA-TRT comments; USFWS (2004) Draft Recovery Plan for the Coastal-PugetSound Distinct Population Segment of Bull Trout (*Salvelinus confluentus*). Volumes I (Puget Sound Management Unit, 389 + xvii pp.) and II (Olympic Peninsula Management Unit, 277 + xvi pp.).
Forage fish: critical areas (mostly spawning beaches)	Ruggerone and Goetz , CJFAS (2004); WDFW Fish and Wildlife Science, Online Science Magazine (Bargman 2001); MRC/NW Straits (2005) Assessment of Shoreline Spawning Habitats in the Northwest Straits (2001-2004) (for location of spawn beaches)
Miles of shoreline, shoreline armoring, eelgrass, kelp, marine riparian cover, railroads, overwater structures, exotic plant species.	Nearshore Habitat Program. 2001. The Washington State ShoreZone Inventory. Washington State Department of Natural Resources, Olympia, WA. (Abbreviated below as ShoreZone, 2001); Washington DOT (railroads); Washington DOE Digital Coastal Atlas; Washington DOE cruise ship report (2005)
1. Sub-basin delineation 2. Area of nearshore (below MHHW), area of offshore, total area	1. See in Section 2 2. CommEn Space and PSAT GIS analysis based on bathymetry (Finlayson 2005) and ShoreZone (2001)
Location and character of pocket estuaries	See Appendix B
Location and character of major drift cells	See Appendix C
Identification of bays	PSAT staff judgment
Estuaries of major rivers (11 natal estuaries for Puget Sound Chinook salmon)	PSAT GIS analysis (See Appendix A)
Development and delineation of 5- and 10-mile buffers around natal deltas	CommEn Space and PSAT GIS analysis based on the 5- and 10-mile criteria suggested by Kurt Fresh, NOAA-NWFSC (see discussion about fry migrant use of non-natal estuaries in Section 3)
Land Cover	U.S. Geological Survey (USGS) Publication Date: 19990631 Title: Washington Land Cover Data Set Edition: 1
Loss and simplification of estuarine wetlands	Bortleson et al. (1980); Collins et al. (2003)
Alteration of flow through major rivers	Bull trout recovery plan (USFWS 2004)

Salmon and Bull Trout Use, Ecosystem Feature, Landscape Class, Stressor or Threat	**Source of Information for Sub-Basin Assessment**
Urbanization of small drainages (for only those drainages to pocket estuaries)	Pocket estuary analysis - see Tables in Appendix E.
Discharges: 1. Municipal and industrial 2. Stormwater 3. On-site sewage 4. Wastewater and other discharges from vessels	Not specifically addressed.
Spills (oil, chemicals, other)	Identification of industrial lands along marine shorelines from land use map
Toxic contaminants 1. Sediment sites 2. Water Column	1. Sediment contamination from 2002 Puget Sound Update (PSAT 2002a). 2. Where possible - WDFW/NOAA fish contaminant monitoring data (2004)
Finfish aquaculture operations (hatcheries, net pens)	Shared Strategy map of hatchery locations; NOAA technical report (NASH 2001)
Chinook, summer chum, bull trout occurrence (if possible, utilization) in freshwater streams other than rivers entering 11 natal estuaries	Salmon and Steelhead Analysis Inventory and Analysis Program (SSHIAP), WDFW.

6.1 South Georgia Strait

A. Assessment

1. Salmon Use

Chinook

This is part of the South Georgia Straits and San Juan Islands region, which includes two independent populations, both of which emanate from this sub-basin:

- North Fork Nooksack
- South Fork Nooksack

a) Juvenile

- Juvenile Chinook salmon of all four life history types of the Nooksack populations, and larger juveniles from throughout Puget Sound (particularly from the Skagit River), utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon have been shown to utilize small (and large) freshwater streams for direct rearing. The Dakota Creek – Point Roberts area is part of the geomorphic structure of the Fraser River delta that contains estuarine rearing habitats supporting natal Chinook outmigrants. The area is also believed to provide significant rearing potential to juvenile Chinook emanating from rivers in other sub-basins. We hypothesize this non-natal support is especially important to the northern Puget Sound populations (i.e., see Table 3-1 for the list of northern Puget Sound populations).

b) Adult

- Adult Chinook salmon of the North Fork and South Fork Nooksack populations and from other Puget Sound populations utilize the South Georgia Strait (Kurt Fresh [NOAA-NWFSC], Bill Graeber [NOAA-TRT], pers. comm.). In addition to Dakota Creek mentioned above, Chinook salmon are documented as using the Lummi River (Figure E-1.1 in Appendix E).
- Adult salmon from far outside Puget Sound (e.g., Columbia River ESU's) are known to frequent this sub-basin (Kurt Fresh [NOAA-NWFSC], Bill Graeber [NOAA-TRT], pers. comm.).

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. Non-natal use may occur, but it is not known for certain. This sub-basin is outside the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU
- Bull trout (anadromous): Occurs in one core area (Nooksack) in this sub-basin. The core area contains an estimated 10 local populations, fewer than 1000 adults (estimated) and an unknown population trend (numbers generally low) (USFWS 2004). The Nooksack core

area is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound.

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

In the Strait of Georgia, the peak abundance of zooplankton has shifted from the month of May (1960s and 1970s) to April (1990s), presumably due to higher temperatures (Ruggerone and Goetz, 2004). Pacific herring are one type of forage fish that prey heavily upon zooplankton (West, 1997), and herring and other small schooling fish are thought to be an important part of the diet of salmon (Bargman 2001) and bull trout (USFWS 2004). In this sub-basin, Cherry Point herring, once the largest stock in Washington with spawning grounds extending from north Bellingham Bay to the Canadian border, have declined 94% from historic levels (Bargman 2001). Suspected causes for decline are discussed below. Cherry Point herring are a spring spawning stock, different from the other herring stocks in Washington, which are winter spawning stocks (e.g., Semiahmoo Bay herring stock in this sub-basin) (Bargman 2001). Many early spawning stocks in Puget Sound have not declined as much as the Cherry Point stock (Ruggerone and Goetz, 2004).

The major 1982-1983 El Nino event is thought to have affected survival of Puget Sound Chinook since that time (Ruggerone and Goetz, 2004). In the Strait of Georgia, most pink salmon enter marine waters in April, before Chinook salmon, and during even-numbered years. Prior to the large El Nino event, Chinook experienced greater survival during even-years, but since the El Nino event of 1982-1983 survival has been reduced, and Ruggerone and Goetz (2004) have hypothesized this is due to increased competition with pink salmon for prey resources. As a result, juvenile Chinook salmon may be entering marine waters at a time of reduced prey availability (Ruggerone and Goetz, 2004). In addition, the substantial decline in spawning Cherry Point herring during the early 1980s coincides with the reduced survival of Chinook and an increase in pink salmon abundance (Ruggerone and Goetz, 2004).

Landscape Conditions

In general, shorelines within the South Georgia Strait sub-basin are open to large fetches from the southwest and are therefore susceptible to wave-dominated processes like strong nearshore drift. This part of the sound also has reduced tidal amplitude compared to points further south and so waves have the opportunity to rework sediments in a finer elevation band along the shoreline. While the waters of South Georgia Strait generally exchange well through tidal action with Pacific Ocean waters, there are several places where localized oceanographic conditions create recirculating gyres which tend to increase water residence times making those waters susceptible to eutrophication and other water quality problems. (Refer to Appendix E, Figures E-1.1 through E-1.5.)

Overall area (shown in Figure 2-3 in Section 2)

- Total area (deep-water plus nearshore) is 279,999 acres (437.5 square miles).
- Deep-water portion (marine waters landscape class) comprises 216,703 acres (338.6 square miles), or 77% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 63,295 acres (98.9 square miles), or 23% of the total sub-basin area. As part of the nearshore, the Nooksack estuary (landscape class) is a natal estuary for the independent Chinook populations listed above, comprising 43.79 square miles (44%) of the total nearshore area within this sub-basin (Figure E-1.1, Appendix E).
- Nearshore area within this sub-basin is 15% of the nearshore area of the entire Puget Sound basin.
- Contains 218 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Semiahmoo Bay, Birch Bay, Lummi Bay, Bellingham Bay, and Chuckanut Bay (Figure E-1.1, Appendix E).
- Thirty-one linear miles (14%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 46% of the shoreline (101 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 17% of the shoreline (38 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 35% of the shoreline (77 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

Our visual analysis of pocket estuaries in this sub-basin revealed 14 pocket estuaries: two in Drayton Harbor, three in Birch Bay, seven within Bellingham Bay, one on Lummi Island and one on Point Roberts (Figure E-1.4, Appendix E). Among the results were:

- Freshwater sources were observed in all but two of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in 11 of the 14 pocket estuaries.
- Composite "scores" were generated for each pocket estuary based on likely Chinook functions and stressors observed during analyses. None of the pocket estuaries were estimated to be *properly functioning*. Four of the 14 were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk* (Figure E-1.2, Appendix E).

Drift Cell Analysis

A drift cell characterization for this sub-basin is presented in Appendix E, Figure E-1.5 and subsequent text. Broad intertidal and subtidal shelves that provide shallow, vegetated patches and corridors along the shoreline are a depositional feature of soft sediments generally at the depositional portions of drift cells or at the intersection of longshore drift and deltaic processes Descriptions of littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration of longshore drift functions are presented in Appendix E. Recommendations for protection and restoration are highlighted in Tables 6-2 and 6-3.

Threats/Stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Nooksack delta, the estimated area of intertidal wetlands increased from 2.59 to 3.28 square miles (increased by 0.69). In this same delta, the estimated area of subaerial wetlands increased from 1.73 to 1.77 square miles (increased by 0.04). However, the lack of dendritic channel structure in the newly created delta may result in a loss of accessible habitat for delta fry life history type Chinook. For the Lummi delta, the estimate area of intertidal wetlands decreased from 5.40 to 5.01 square miles (decreased by 0.39). In this same delta, the estimated area of subaerial wetlands decreased from 2.24 to 0.12 square miles (decreased by 2.12). Historically, the Nooksack mainstem contained floodplain wetlands and extensive estuarine marshes, but now a less complex channel pattern exists for the upper Nooksack mainstem, due in part to levees and isolating meanders (Collins et al, 2003).

Alteration of flows through major rivers

A City of Bellingham diversion dam is located on the Middle Fork Nooksack River, but is without a reservoir and does not interrupt sediment or large woody debris movement (USFWS 2004). A formerly abandoned, but recently employed hydropower facility is located on the North Fork Nooksack River (USFWS 2004). Additional diversions of the Nooksack occur for irrigated agriculture, industrial uses at the Cherry Point refinery complex and the cities of Lynden and Ferndale. In all these cases flow is reduced from within the Nooksack channel.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Whatcom County between 2000-2025 is 48% (79, 822 people) (PSAT 2005). Shoreline armoring occurs along 47.1 miles (21.3%) of the shoreline (Figure E-1.3, Appendix E). Over 39 miles of shoreline are classified as 100% armored. Nearly 152 miles are classified as 0% armored. The total number of overwater structures in this sub-basin is 2,843, consisting of ramps (118), piers and docks (257), small slips (2,401) and large slips (67). These structures are observed in greater concentrations in Drayton Harbor, Birch Bay, Sandy Point, and Bellingham Bay. Within 300 feet of shore, railroads occur along 8.5 miles of shoreline, from Chuckanut north to Bellingham and sections of Bellingham Bay, and again at the northeast section of Drayton Harbor.

Contamination of nearshore and marine resources

Industrial shorelines are located in several locations of this sub-basin, including Bellingham Bay and the Cherry Point region. The Cherry Point area experiences substantial shipping and petroleum movement, which occurs in the region of herring spawning grounds (Bargman 2001). A study conducted by the University of Washington, in response to potential contamination of herring spawning grounds, revealed that at Cherry Point the herring experienced a) low hatching rates from eggs, b) smaller newly hatched larvae, and c) high rate of abnormal development (Bargman 2001). Alternative hypotheses are being investigated regarding these abnormalities at this time.

Bellingham Bay is one of three locations sampled ('historic' data set from 1989 through 1996 compared to 2000) where PAH levels increased (PSAT 2002a).

Analysis of sediment samples in randomized site locations between 1997 and 1999 showed Bellingham Bay is one of several urban locations with extensive sediment contamination: 10% of the Bellingham Bay area exceeds state sediment quality standards and 2.1% exceeds cleanup screening levels (PSAT 2002a). Impaired invertebrate communities were identified in Bellingham Bay (PSAT 2002a).

Five sewage outfalls (Figure E-1.3, Appendix E) and an unknown number of stormwater discharges are also observed in this sub-basin.

Water quality impairments in this region are indicated in Figure E-1.3 (Appendix E).

Alteration of biological populations and communities

An unknown number of hatcheries, net pen facilities, and shellfish operations are found in this sub-basin. Specific hatchery reform recommendations formulated for this region by the Hatchery Scientific Review Group are presented at:
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Figure E-1.2, Appendix E, presents land cover information for the lands surrounding this sub-basin. Figure E-1.4, Appendix E, lists pocket estuaries and notes stressors observed from review of oblique aerial photos. We determined that Whatcom Creek, Squalicum Creek, Birch Bay and Point Roberts pocket estuaries are not properly functioning due to urbanization impacts to juvenile salmon functions (Figure E-1.4, Appendix E). Given current development pressure, we determined that Chuckanut Creek, Padden Creek, Terrell Creek, California Creek and Dakota Creek pocket estuaries are at risk of losing functions due to urbanization.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp. is not recorded in this sub-basin. However, 41% of the shoreline (90 miles) contains *Sargassum muticum*.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) of Nooksack Chinook salmon populations: connectivity of habitats, prey resources
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area
c) Maintain anadromous life form of bull trout by preserving forage fish species and marine foraging areas. Provide marine support for sub-adult and adult anadromous bull trout populations as foraging, migration, and overwintering habitat
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook and bull trout
e) Provide early marine support for independent spawning aggregations of Chinook occurring in this sub-basin.

Goal for listed salmon and bull trout whose natal streams are in other sub-basins

a) Provide support for all neighboring Puget Sound populations, the Skagit River Chinook populations in particular, as well as Fraser River (Canada) populations and larger juveniles from other sub-basins.

Realized function for listed salmon and bull trout

Fry migrant Chinook – The condition of pocket estuaries within 5 and 10 miles of the Nooksack estuary (Figure E-1.2 in Appendix E) suggests that Chinook fry migrants may not be well supported unless conditions are improved through restoration. Fry migrants utilizing pocket estuaries and shorelines of Bellingham Bay may not be supported because of poor water quality, loss of large expanses of eelgrass, and loss and degradation of smaller estuaries and shallow water. Fry migrants may experience similar disruptions to their migratory corridors as delta fry. Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type.

Delta fry Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). In addition, delta fry in Bellingham Bay are likely to have a higher level of exposure to toxic contaminants than other life history types. Delta fry that emerge as parr may encounter only minor disruptions in their migratory corridor if they travel northward toward pocket estuaries in Drayton Harbor and Birch Bay but potentially more frequent and intense interruptions if they migrate southward to Padilla and Samish Bays because of a higher degree of shoreline clearing, armoring and wastewater discharges in Bellingham Bay. However, the role of the extensive eelgrass bed within Padilla Bay may support migrating parr in a way that is currently not understood. The opportunity for delta fry to access intertidal areas of the Lummi delta are severely curtailed. Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Parr migrant Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). Any oil spills from the industrial center of Cherry Point and Bellingham Bay are a threat to this life history type if present at the time of the spill. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Yearling Chinook – During even-numbered years, juvenile Chinook salmon of this life history type may be entering marine waters at a time of reduced prey availability due to competition with pink salmon for resources (Ruggerone and Goetz, 2004). Any reduction in capacity as a result of non-support of the three smaller life history types within this sub-basin will potentially negatively affect yearling migrants. It is expected that parr migrating northward from Padilla/ Samish bays and other sub-basins to the south may be a significant source of food for yearling migrants. Yearlings will also require access to forage fish resources within the sub-basin. Any smaller life history types affected by an oil spill from the industrial center of Cherry Point or Bellingham Bay may also affect this life history type through lower prey availability or threat of toxic contamination of the food chain. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Sub-adult and adult Chinook – We hypothesize that the survival of sub-adults and adults may be impacted by a decrease in abundance of Cherry Point herring. Water diversions and resulting high temperatures in the delta may affect migration and subsequent spawning success.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum do not use this sub-basin.

Anadromous bull trout – Sub-adult and larger adult anadromous bull trout forage and migrate through nearshore and estuarine areas in and around Bellingham Bay (including Whatcom Creek, and historically Squalicum Creek), and may exploit areas further north and south of the Nooksack estuary (USFWS 2004). Prey availability, condition of prey (contamination), as well as availability, and access to productive regions are likely critical to sustaining this life history type in this sub-basin.

Table 6-2. Recommended Protection Actions for the South Georgia Strait

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Aggressively protect areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of Nooksack River	Early marine support of all 4 life history types of Nooksack Chinook populations (feeding and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	
Protect small creeks, and larger creeks such as Dakota Creek.	Provides habitat diversity across the landscape and spatial structure to the Nooksack population.	Provides direct rearing utilization by juveniles from adjacent sub-basins	
Protect shorelines and marine regions used for spawning by Cherry Point herring stock.	Provides prey for larger juveniles (feeding and growth); and sub-adults	Provides prey for larger juveniles (feeding and growth); and sub-adults	Provides forage base for anadromous bull trout
Protect against catastrophic events (e.g., oil spills)	Allows for the possibility of all four juvenile functions to be realized; foraging areas, connectivity, and migration pathways for sub-adults and adults	Allows for the possibility of one or more juvenile functions to be realized; foraging areas, connectivity, and migration pathways for sub-adults and adults	Bull trout: connectivity of habitats, marine/estuarine foraging areas, prey resources
Protect from further armoring and overwater structures of any shoreline property located within green boxes 1,2,3 and 5 on the map in Figure E-1.5, Appendix E. These are important feeder sources for long, functioning drift cells within the South Georgia Strait sub-basin.	(see benefits to other Chinook)	Functioning littoral drift and sediment regime for beach maintenance and spit formation – pocket estuary and lagoon formation; forage fish spawning locations. Can address up to all four juvenile functions	Provides marine and estuarine foraging areas and prey resources
Protect functioning drift cells that support eelgrass bands and depositional features along Birch Bay and Drayton Harbor shorelines as well as Portage and Lummi Island shorelines.	Provides for feeding and growth, refuge and migration for older life history types – parr migrants and yearlings (and sub-adults?)	Provides for feeding and growth, refuge and migration for older and larger juveniles (and sub-adults)	May provide foraging locations for bull trout
Protect upland sediment sources in the rust-colored boxes 4 and 7 on the map in Figure E-1.5, Appendix E by assuring that water resources planning allows for seasonal overbank flooding which delivers sediment and wood debris to these deltas.	Provides for feeding and growth and refuge for older and larger life history types; sub-adults	Provides for feeding and growth, refuge and potentially osmoregulatory functions for juveniles; sub-adults	Provides for foraging locations and prey resources for bull trout
Removal of tide gates where beneficial and possible.	Increased area for which juveniles may exploit – up to all four functions may be satisfied.	Increased area for which juveniles may exploit – up to all four functions may be satisfied.	

Table 6-3. Recommended Improvement Actions for the South Georgia Strait

Improvement Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Let natural processes control and accomplish reconnection of Nooksack/Lummi. Goal: create substantially more estuarine habitats. Re-creation of the Lummi River delta represents a riverine estuary restoration potential of regional significance. Could recover an increment of the 70 percent historic loss of this habitat type in a block large enough to restore ecologic processes at the regional scale. Few opportunities to restore a fully functional riverine delta exist.	Increased landscape connectivity via more estuarine habitats will benefit delta fry, especially, but also fry migrants and parr migrants (feeding and growth, refuge, osmoregulation, migration functions).	Increased landscape connectivity via more estuarine habitats will benefit larger juveniles (feeding and growth, refuge, migration functions)	Bull trout could potentially benefit from the expansion of habitat area – increased foraging opportunities, prey base.
Aggressively restore areas, especially shallow water/low gradient habitats and pocket estuaries, w/in 5 miles of Nooksack River	Early marine support of all 4 life history types of Nooksack Chinook populations (feeding and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	
Restore small creeks (and some larger creeks such as Dakota Creek)		Provides direct rearing utilization by juveniles from adjacent sub-basins	
Implement local actions that will contribute to the recovery of the Cherry Point herring spawning populations	Provides feeding and growth benefit to larger juveniles (potentially) and sub-adult and adults.	Support for neighboring Puget Sound populations (e.g., Skagit Chinook, larger juveniles, Fraser River populations) and sub-adults and adults. Functions addressed: feeding and growth	Provide for increased forage base and foraging area for bull trout.
Cap toxic sediments in Bellingham Bay; control amount of sediment reaching Bellingham Bay; address contamination concerns along industrial shoreline regions (e.g., Cherry Point).	Prevents contamination of the food web for all four life history types; sub-adults and adults. Decommission roads in watershed will limit sediment input which will benefit spawning adults	Prevents contamination of the food web for neighboring populations; sub-adults and adults	Prevents contamination of the food web for anadromous bull trout

6.2 Padilla/Samish Bay

A. Assessment

1. Salmon Use

Chinook

This is part of the Whidbey Basin and Padilla and Samish bays region, which includes independent populations in the Skagit, Stillaquamish, and Snohomish river systems but none from the streams draining directly to this sub-basin.

a) Juvenile

- Juvenile Chinook salmon the Skagit River system historically utilized the three bays in this sub-basin (Padilla, Samish, and Fidalgo) as part of their natal Skagit River delta. Due to alterations in the delta this area is no longer directly accessible to outmigrant Skagit Chinook.
- Juvenile Chinook salmon from the Nooksack populations utilize this sub-basin area for feeding and growth, refuge, physiological transition and as a migratory corridor.
- The area also likely provides significant rearing potential to larger non-natal juvenile Chinook from other sub-basins, perhaps primarily for the northern Puget Sound populations.

b) Adult

- Adult Chinook salmon from non-natal populations (e.g., Nooksack, Skagit) are presumed to utilize this sub-basin. Chinook are documented to use other regions in this sub-basin, including Samish River, Colony Creek, and Indian Slough. It is presumed they also use Edison Slough. See Figure E-1.1 for the distribution.
- It is not known if adult salmon from far outside Puget Sound frequent or utilize this sub-basin

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. Non-natal use may occur, but it is not known for certain. This sub-basin is outside the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU.
- Bull trout (anadromous): Preliminary core populations (from core areas) within the Puget Sound Management Unit of bull trout are not present in this sub-basin. However, the Samish River (and Friday Creek) provides important foraging, migration, and overwintering habitat for sub adult and adult anadromous bull trout (USFWS 2004). Several salmon species and steelhead is a forage base for anadromous bull trout. Samish River habitat is especially important to proximate bull trout populations (e.g., Nooksack, Skagit populations) (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Oceanographically, the Padilla/Samish sub-basin is part of the historic Skagit delta where deltaic processes are no longer active. However, the historic flow of fine sediments into Padilla Bay has created a broad, shallow basin making almost the entire bay intertidal. Padilla Bay and Samish Bay both experience reduced mixing since agricultural dikes reduced the freshwater inflow into the area. Samish Bay still has the influence of the Samish River and Edison slough freshwater and sediments. Nutrient implications for the sub-basin include potential eutrophication from agricultural sources. Forage fish (specifically Fidalgo Bay population of herring are important to salmon. Primary/secondary productivity for the system is high because of the extensive eelgrass meadow in Padilla Bay. It is expected that significant amounts of detritus is exported from Padilla Bay to neighboring San Juan Islands and South Georgia Strait sub-basins. The eelgrass also helps to support a thriving Dungeness crab fishery. Padilla Bay is designated as a National Estuarine Research Reserve and contains one of the largest eelgrass beds on the West Coast, providing habitat for many species.

Landscape Conditions

Even though these bays are shallow, significant open water fetch can create waves on the bays and move nearshore sediments along certain key features such as Samish Island and March Point. However, the western margin of this sub-basin contains rocky shorelines that are resistant to longshore drift processes and contain fringing kelp beds. See Figures E-1.1 through 1.3, E-2.4 and 2.5 for depictions of landscape conditions in this sub-basin.

Pocket Estuary Analysis

Our visual analysis of pocket estuaries in this sub-basin revealed seven pocket estuaries: four in Samish Bay and three in Padilla Bay (Figure E-2.4, Appendix E). Among the results were:

- Freshwater sources were observed in all but one of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in six of the seven pocket estuaries.
- Composite "scores" were generated for each pocket estuary based on likely Chinook functions and stressors observed during analyses. Two pocket estuaries were estimated to be *properly functioning*. One pocket estuary was estimated to be *not properly functioning*. The remaining four pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

As in other sub-basins with rocky shorelines, the action of longshore sediment drift processes has reduced importance in shaping the nearshore landscape in this sub-basin. Samish Island is a notable exception. Extensive shallow mudflats that do not appear to move alongshore, but are critical deltaic features of the landscape dominate the eastern shoreline of the sub-basin.

Overall area

- Total area (deep-water plus nearshore) is 52,416 acres (81.9 square miles).
- Deep-water portion (marine waters landscape class) comprises 9,856 acres (15.4 square miles), or 19% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 42,560 acres (66.5 square miles), or 81% of the total sub-basin area. A natal estuary (landscape class) is not present in this sub-basin (Figure E-1.1).
- Nearshore area within this sub-basin is 10% of the nearshore area of the entire Puget Sound basin.
- Contains 100 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Padilla Bay, Samish Bay, and Fidalgo Bay (Figure E-1.1, Appendix E).
- Ten linear miles (10%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 73% of the shoreline (73 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 8% of the shoreline (8 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 17% of the shoreline (17 linear miles) has non-floating kelp; may be patchy or continuous.

The drift cell analysis for this sub-basin is presented in Appendix E, Figure E-2.5 and subsequent text. Recommendations for protection and restoration presented in the Appendix are highlighted in Tables 6-4 and 6-5.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Samish delta, the estimated area of subaerial wetlands decreased from 0.73 to 0.15 square miles (decreased by 0.58). The estimated loss or gain of intertidal wetlands is not available. Historically, estuarine wetlands were extensive in the Skagit-Samish delta, consuming an area more than twice that of the Nooksack, Stillaguamish and Snohomish deltas, combined (Collins et al, 2003). Diking and draining of wetlands has reduced the area. The loss of side channel regions and riparian vegetation in floodplains and estuarine areas can be attributed to such activities as agricultural practices (USFWS 2004).

Alteration of flows through major rivers

The isolation of the nearshore habitats of this sub-basin from the flow of the Skagit River system represents a significant historic flow alteration.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

Shoreline armoring occurs along 50.9 miles (51.6%) of the shoreline (Figure E-1.3, Appendix E). Over 47 miles of shoreline are classified as 100% armored. Nearly 38 miles are classified as 0% armored. The total number of overwater structures in this sub-basin is 1,868, consisting of ramps (29), piers and docks (79), small slips (1,726) and large slips (34). These structures are observed in greater concentrations in the northeast section of Fidalgo Island in the area of Anacortes. Within 300 feet of shore, railroads occur along 9.5 miles of shoreline, from near Windy Point in Samish Bay northward to Larrabee State Park, and the northeast section of Fidalgo Island.

Contamination of nearshore and marine resources

Potential contamination sources in Padilla Bay include failing septic systems, stormwater runoff, poor agricultural practices (including dairy farming), and industrial and commercial development.

Two sewage outfalls (Figure E-2.3, Appendix E) and an unknown number of stormwater discharges are also observed in this sub-basin.

Water quality impairments are indicated in Figure E-1.3, Appendix E.

Alteration of biological populations and communities

There are five fish hatcheries on or directly adjacent to this sub-basin with unknown effects on competition and community structure. Refer to the hatchery reform recommendations of the Hatchery Scientific Review Group at the following website.
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Rural development and suburban sprawl is an increasing threat within the agricultural region of Padilla Bay (citation in Estuarine Research Federation Spring 2003 Newsletter). Fidalgo Bay and Edison Slough are among the pocket estuaries degraded by urbanization within this sub-basin (Figure E-2.4, Appendix E). See Figure E-2.4 for an evaluation of pocket estuaries and stressors noted through review of oblique aerial photos. Figure E-1.2, Appendix E, presents land cover information for the area surrounding this sub-basin.

Transformation of habitat types and features via colonization by invasive plants

In this sub-basin, 5% of the shoreline (5 miles) contains patchy or continuous *Spartina spp*. Also, 18% of the shoreline (18 miles) contains patchy or continuous *Sargassum muticum*. *Spartina alterniflora* has nearly been eradicated from Padilla Bay, but seedlings from *S. anglica* are present in adjacent bays and require annual monitoring and control (citation from Estuarine Research Federation Spring 2003 Newsletter).

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout

a) Provide support for all neighboring Puget Sound populations, particularly the Skagit River and Nooksack River Chinook salmon populations
b) Provide foraging, migration and overwintering habitats for neighboring populations of bull trout.
c) Support spatial structure & diversity VSP parameters for all salmon populations
d) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Realized function for listed salmon and bull trout

Fry migrant Chinook – Fry migrants from both the Nooksack and Skagit estuaries are likely to use this entire sub-basin, not just the pocket estuaries, as the shallow water, mudflats and eelgrass beds support similar functions as pocket estuaries (Figure E-1.2, Appendix E). The existing unarmored shorelines and three fully functioning pocket estuaries support this life history type very well. During high tides and storm events, however, all seven pocket estuaries may be needed to support refuge functions. Chemical stressors and sewage outfalls likely affect Nooksack fry migrants as they move into Samish Bay. Water quality impacts from agricultural runoff can affect this life history type throughout the sub-basin. Connectivity between Padilla Bay and the Skagit estuaries is limited for fry migrants from the Skagit and other river systems in Whidbey Basin. Spartina infestations could impact this life history type by blocking channels with sediment. Any oil spills from March Point are a threat to this life history type. Because of the loss of historic connection of this sub-basin to the Skagit delta, there is a loss of opportunity and capacity from Skagit populations. Moreover, degradation of Fidalgo Bay results in a loss of capacity for this life history type.

Delta fry Chinook – No delta fry life history types are expected to be present in this sub-basin unless extreme flood events transport delta fry from the Nooksack estuary to the north or the Skagit estuary to the south. In such an event, the extensive mudflat and eelgrass habitats within this sub-basin would support delta fry. Significant improvement to this function could be realized by removal of dikes fronting both Samish and Padilla bays eastern shorelines. Spartina infestation will likely have little adverse impact to this life history type unless infestations begin to block existing channels. Any oil spills from March Point are a threat to this life history type. Because of the loss of historic connection of this sub-basin to the Skagit delta, there is a loss of opportunity and capacity from Skagit populations. Moreover, degradation of Fidalgo Bay results in a loss of capacity for this life history type.

Parr migrant Chinook – A diversity of habitat types exist for parr migrants in this sub-basin. Opportunity to access them for populations from the Whidbey sub-basin is constrained as mentioned above for fry migrants. Spartina infestations could affect parr migrants seeking nearshore channel structure in salt marshes. Oil spills from March Point could pose a threat to this life history type if they are present at the time of the spill. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type. Because of the loss of historic connection of this sub-basin to the Skagit delta, there is a loss of opportunity and capacity from Skagit populations. Moreover, degradation of Fidalgo Bay results in a loss of capacity for this life history type.

Yearling Chinook - Any reduction in capacity as a result of non-support of the three smaller life history types within this sub-basin will negatively affect yearling migrants. It is expected that parr migrating from other sub-basins to the south and north will be a significant source of food for yearling migrants. Yearlings will also require access to forage fish resources within the sub-basin, which are considerable. Any smaller life history types affected by an oil spill from March Point will also affect this life history type through lower prey availability or threat of toxic contamination of the food chain. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type. Because of the loss of historic connection of this sub-basin to the Skagit delta, there is a loss of opportunity and capacity from Skagit populations. Moreover, degradation of Fidalgo Bay results in a loss of capacity for this life history type.

Sub-adult and adult Chinook – Survival of sub-adult and adult Chinook salmon is dependent on several factors, including the production and availability of forage fish species within nearshore regions, marine vegetation such as eelgrass and kelp, and water quality. We hypothesize that during even-numbered years, Chinook salmon may experience increased competition with pink salmon for resources.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum do not use this sub-basin.

Anadromous bull trout – Even though this sub-basin does not contain core area populations, sub-adult and adult anadromous bull trout from nearby populations utilize regions of this sub-basin as foraging, migration and overwintering habitats.

Table 6-4. Recommended protection actions for Padilla/Samish Bay

Protection Action	Benefit to Natal Chinook	Benefit to other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Aggressively protect unarmored shorelines, especially along the west shore of Padilla Bay and all shorelines of Guemes Island	Protects features which may support rearing of fish from independent spawning aggregations	Protects shallow subtidal shelves supporting vegetated migration corridors for Nooksack and Skagit migrants	
Protect Fidalgo Bay herring	N/A	Protects feeding function	Protects feeding function

stock (support both staging and spawning functions in this area)		for all populations migrating through this sub-basin	for anadromous bull trout
Continue protections of large eelgrass meadow (2nd largest on the west coast) in Padilla Bay.	Protects features which may support rearing of fish from independent spawning aggregations	Vegetative cover for migration, feeding of Skagit and Nooksack parr migrants, yearlings	Protects feeding function for anadromous bull trout
Protect against further *Spartina* infestations.	Protects features which may support rearing of fish from independent spawning aggregations	Protects existing physiological transition, feeding and refuge functions for Skagit and Nooksack, other migrating populations	
Aggressively protect Joe Leary Slough, Indian Slough and Samish River delta estuaries	Protects features which may support rearing of fish from independent spawning aggregations	Protects existing physiological transition, feeding and refuge functions for Skagit and Nooksack, other migrating populations	Protects feeding function for anadromous bull trout

Table 6-5. Recommended improvement actions for Padilla/Samish Bay

Improvement Action	**Benefit to Natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Continue to mechanically remove *Spartina* colonies	May improve rearing of fish from independent spawning aggregations	Increase native cover and feeding support for Nooksack and Skagit migrants	
Improve connections between the Skagit delta and Padilla Bay to support two-way movement of fish	May improve rearing of fish from independent spawning aggregations	Support feeding and refuge functions of the Skagit such as fry and parr outmigrants, particularly of the delta fry life history type.	Would improve access/connectivity between the Skagit delta and neighboring deltas for bull trout feeding
Remove agricultural dikes along the south shoreline of Padilla and Samish Bays where feasible	May improve rearing of fish from independent spawning aggregations	Support feeding and refuge functions of the Skagit such as fry and parr outmigrants, particularly of the delta fry life history type.	Would improve access/connectivity between the Skagit delta and neighboring deltas for bull trout feeding
Consider wastewater reclamation and reuse retrofits for Anacortes wastewater discharge	May improve rearing of fish from independent spawning aggregations	Reduced physiological stress from nutrient loading and potential eutrophication	Reduced physiological stress from nutrient loading and potential eutrophication

6.3 Eastern Strait of Juan de Fuca

A. Assessment

1. Salmon Use

Chinook

This is part of the Eastern Strait of Juan de Fuca and Admiralty Inlet region, which includes two independent populations, both of which emanate from this sub-basin:

- Elwha
- Dungeness

a) Juvenile

- Juvenile Chinook salmon of all four life history types of the Dungeness and Elwha populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Larger juvenile Chinook salmon and older life history types from non-natal populations are often found to utilize habitats and landscape features in this sub-basin. We hypothesize that Chinook from all 22 populations utilize the sub-basin's nearshore as a migratory corridor (see Table 3-1 for the list of Puget Sound populations).

b) Adult

- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a passage corridor and grazing area. Other than the Dungeness and Elwha, Chinook are documented to use Morse Creek and other regions in the eastern Strait (Figure E-3.1)
- Adult salmon from far outside Puget Sound (e.g., Columbia River and Snake River ESU's) may utilize habitats within this sub-basin as a passage corridor and grazing area.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Two natal populations (Jimmy Comelately, Salmon/Snow) of the Hood Canal/Eastern Strait of Juan de Fuca Summer chum ESU exist in this sub-basin. We hypothesize that all populations of Hood Canal/Eastern Strait of Juan de Fuca Summer chum utilize the sub-basin's nearshore as a migratory corridor. Historically, summer chum were documented to have used Johnson's Creek.
- Bull trout (anadromous): Occurs in two core areas (Elwha, Dungeness) in this sub-basin. The Elwha core area contains one identified local population, but additional populations may exist. The status is unknown for this core area, but few individuals exist in the Elwha population (USFWS 2004). The Dungeness core area contains two populations, of unknown status. Bull trout use has also been documented in Ennis Creek, Bell Creek, Seibert Creek, and Morse Creek.

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Shaffer and Crain (2004) summarize ecological conditions in this sub-basin as follows:

> The north Olympic Peninsula has extensive shorelines that border the Strait of Juan de Fuca and the Pacific Ocean. More than 80% of the water from Puget Sound and the Strait of Georgia flows through the Strait of Juan de Fuca (Mackas and Harrison 1997). Direction of net water movement within the Strait of Juan de Fuca depends on depth. Net movement of cold oceanic deep water is to the east while net movement of fresher, warmer surface water is to the west (Mackas and Harrison 1997; Strickland 1983).
>
> The Strait of Juan de Fuca is a wind-dominated system, with currents changing dramatically within hours in response to both regional and larger scale oceanic winds (Hickey 1996; Strickland 1983). Strong seasonal storms contribute pulses of both freshwater and sediment to the Strait of Juan de Fuca. These pulses will form large lenses of very low salinity and very high turbidity within the nearshore zone along the majority of the shoreline of the Strait of Juan de Fuca. These lenses appear to occur primarily during winter and spring months. Due to deep oceanic water and strong wind and current mixing action, as well as seasonal strong contribution of riverine nutrients, the water of the main basin is well-mixed, cold, and nutrient-rich throughout the year (Mackas and Harrison 1997). This is in direct contrast to the shallow enclosed embayments of the Strait of Juan de Fuca, which may be seasonally stratified and, in some instances, nutrient-limited (Mackas and Harrison 1997).

The Elwha River dams and shoreline armoring are largely responsible for sediment starvation along the shoreline within the Elwha drift cell. As a result, the shorelines contain larger substrates and extensive kelp beds.

Forage fish use is highly variable, and surf smelt spawning appears to occur later in the summer than in other areas of Puget Sound, with egg mortality approaching 30% (Shaffer 2004). Forage fish spawn in lower rivers on the Olympic peninsula and have been shown to use kelp beds. Forage fish spawning habitat in the nearshore and riverine environments are extremely important.

Landscape Conditions

Shaffer and Crain (2004) describe nearshore as: "a critical component to marine ecosystems, and the nearshore Strait of Juan de Fuca is a critical component of a functioning Puget Sound ecosystem. It is the conduit for species migrating to and from inland marine waters of Puget Sound and British Columbia."

Continuity and connectivity of eelgrass and kelp beds are important to migrating juvenile and sub-adult salmon from all 22 populations of Chinook and the populations of Hood Canal/Eastern Strait of Juan de Fuca Summer chum

See Figures E-3.1 through E-3.5 in Appendix E for additional characterization of the landscape of this sub-basin.

Pocket Estuary Analysis (includes area west to Elwha River only)

We identified 22 pocket estuaries in this sub-basin: most are located at the southern terminus of Discovery Bay, Sequim Bay, Dungeness Bay and Port Angeles Harbor as seen in Figure E-3.4.

- Freshwater sources were observed in all but six of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in nine of the 22 pocket estuaries.
- Composite "scores" were generated for each pocket estuary based on likely Chinook functions and stressors observed during analyses. Seven pocket estuaries were estimated to be *properly functioning*. Eight pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*. (Fig. E-3.2)

Drift Cell Analysis

Unlike the pocket estuary analysis, drift cell function was considered for major drift cells west to Neah Bay with the Strait of Juan de Fuca. The action of wind-dominated waves on both bluff and deltaic sediments is a strong determining factor on beach structure. The Strait also provides a living laboratory of large-scale drift cell function that happens over shorter time periods than elsewhere in the Sound and so intensive monitoring of sediment transport as a result of restoration actions is very feasible here. The drift cell characterization for this sub-basin is presented in Appendix E, Figure E-3.5 and subsequent text. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of recommendations are presented in Tables 6-6 and 6-7.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Dungeness delta, the estimated area of subaerial wetlands did not change from historical to date of survey in 1980 (0.19 square miles). The estimated area of intertidal wetlands increased slightly from 2.28 to 2.32 square miles. Since the time of the Bortleson report in 1980, the Dungeness region has experienced rapid growth, and the estuary has been altered from historic conditions by conversion to agriculture, development, and altered sediment transport regimes.

Overall area (pertains to that portion of the Strait west to the Elwha River; only the drift cell analysis reflects the entire strait west to Neah Bay)

- Total area (deep-water plus nearshore) is 412,030 acres (643.8 square miles), the largest of all 11 sub-basins.
- Deep-water portion (marine waters landscape class) comprises 363,390 acres (567.8 square miles), or 88% of the total sub-basin area.

Nearshore area (except for information in the first two bullets, all information pertains the entire Strait, west to Neah Bay)

- Nearshore portion comprises 48,640 acres (76 square miles), or 12% of the total sub-basin area. As part of the nearshore, the Elwha and Dungeness estuaries (landscape class) are natal estuaries for the independent Chinook populations listed above, comprising 12.75 square miles (17%) of the total nearshore area within this sub-basin. (Fig. E-3.1)
- Nearshore area within this sub-basin is 12% of the nearshore area of the entire Puget Sound basin.
- Contains 217 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Discovery Bay, Sequim Bay, Freshwater Bay, Crescent Bay, Clallam Bay, and Neah Bay.(Fig. E-3.1)
- 17 linear miles (8%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 34% of the shoreline (75 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 44% of the shoreline (95 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 74% of the shoreline (161 linear miles) has non-floating kelp; may be patchy or continuous. The kelp beds of the Strait of Juan de Fuca are the majority of Washington's coastal kelp resources.

Information is not available from the Bortleson (1980) report for the Elwha delta. The Elwha estuary and wetlands have been altered since construction of two dams, discussed below. The Elwha estuary was historically not large, but the size has decreased since construction of the two dams (Wunderlich et al, 1994).

Alteration of flows through major rivers

Two dams exist on the lower Elwha River. The lowermost dam, Elwha, was constructed in 1910 and both this and the Glines Canyon dam have significantly altered the nearshore and estuary due to a loss of sediment transport. An estimated 17.7 million cubic yards of clay, silt, sand, gravel and cobbles have accumulated behind both dams, and would be released upon dam removal scheduled to begin in 2007 (Elwha River Ecosystem Restoration Implementation, Final Environmental Impact Statement, 1996).

The Dungeness River system is impacted by water withdrawals. On the lower Dungeness River floodplain, tributaries and independent drainages have been diked, levied and channelized. Diking of channels has altered the flow of water in distributary channels.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

In this sub-basin west to the Elwha River only, shoreline armoring occurs along 37 miles (27%) of the shoreline. (Fig. E-3.3) Over 16 miles of shoreline are classified as 100% armored. Nearly 99 miles are classified as 0% armored. In this sub-basin west to Neah Bay, the total number of overwater structures is 1,439, consisting of ramps (33), piers and docks (104), small slips (1,286) and large slips (16). These structures are observed in greater concentrations in Port Angeles, Sequim Bay and Discovery Bay. The railroad no longer operates on the Olympic peninsula, but the railroad grade is still present. Within 300 feet of shore railroad grades occur along 1.8 miles of Eastern Strait shoreline, along Discovery Bay, part of Sequim Bay, and a section of the Port Angeles shoreline.

Contamination of nearshore and marine resources

Non-point pollution via nutrient loading (as well as stormwater and industrial uses) is a significant concern in this sub-basin, and when combined with shoreline alterations in semi-enclosed embayments, macroalgae blooms (e.g., *Ulvoid* mats) can occur which can elicit changes to community structure.

Water quality impairments stressors in this sub-basin are mapped in Fig. E-3.3

Alteration of biological populations and communities

Two hatcheries exist on the lower Elwha River (Wunderlich et al, 1994). Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following website.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf

Shellfish aquaculture occurs primarily within protected bays like Dungeness Bay, Sequim Bay and Discovery Bay.

Transformation of land cover and hydrologic function of small marine drainage via urbanization

Urbanization effects hydrologic function in 7 pocket estuaries within this sub-basin including Cassalery Creek, Morse Creek, Peabody Creek and Valley Creek which provide important sources of freshwater to the nearshore. See Figure E-3.4 for a list of pocket estuaries and stressors noted by review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

In this sub-basin west to Neah Bay, *Spartina spp* are not found. Also, 2.3% of the shoreline (5 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) of Elwha and Dungeness Chinook salmon populations.
b) Provide early marine support for the two natal populations of Hood Canal/Eastern Strait of Juan de Fuca Summer chum.
c) Provide marine support for sub-adult and adult anadromous bull trout populations within the two core areas in this sub-basin (Elwha, Dungeness).
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, juvenile chum, and bull trout.
e) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goal for listed salmon and bull trout whose natal streams are outside this sub-basin

a) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults). All 22 populations of Chinook in Puget Sound, (and presumably all populations of Hood Canal/Eastern Strait of Juan de Fuca Summer chum) utilize nearshore and marine regions of this sub-basin as a migratory corridor.

Realized function for listed salmon and bull trout

Fry Migrant Chinook – Fry migrants from the Dungeness Chinook population are well supported by low energy shorelines, pocket estuaries and Sequim Bay although poor water quality (e.g., low dissolved oxygen, stratification) within Sequim Bay and Discovery Bay (Fig. E-3.1) could be limiting survival at some times of year due to *Ulvoid* blooms. The lack of sufficient low energy shoreline or functional pocket estuaries near the Elwha delta could be limiting support for this life history type (Fig. E-3.2). Fry migrants that use pocket estuaries near Port Angeles may be exposed to higher levels of toxic contaminants. Also, removal of the two Elwha River dams is expected to benefit this life history type.

Delta Fry Chinook – Current conditions for delta fry of the Elwha Chinook population river are diminished but expected to improve greatly as a result of new sedimentation following dam removal. Delta fry in the Dungeness are well supported. Poor water quality in semi-enclosed embayments may impact this life history type. Also, removal of the two Elwha River dams is expected to benefit this life history type. Loss and degradation of small estuaries and shallow water areas has reduced the availability of prey and refuge as well as disrupted migration for this life history type.

Parr Migrant Chinook - Parr migrants emerging from Elwha and Dungeness rivers would be well supported by the diversity of habitat types along this shoreline, however, the high-energy nature of much of this shoreline suggests an added importance for pocket estuaries to act as refuge. Parr migrants will also be a major food source for larger sized life history types migrating toward the ocean from Puget Sound and South Georgia Basin. Poor water quality in semi-enclosed embayments may affect this life history type. Also, removal of the two Elwha River dams is expected to benefit this life history type.

Yearlings – Yearlings will find support in this sub-basin as they are similarly sized to other migrants passing through the region. Nearshore habitat west of the Elwha River is particularly useful because of the extensive kelp beds lining the shoreline. Poor water quality in semi-enclosed embayments may affect this life history type (as discussed above). Also, removal of the two Elwha River dams is expected to benefit this life history type.

Sub-adult and adult Chinook – Survival of sub-adult and adult Chinook salmon is dependent on the production and availability of forage fish species within nearshore regions of this sub-basin. In addition, marine vegetation such as eelgrass and kelp also play an important role in salmon survival. Poor water quality in semi-enclosed embayments may impact this life history type (as discussed above). Removal of the two Elwha River dams is expected to greatly benefit returning spawners, as an additional 70 miles of river will become available for spawning. Adequate adult escapement from the Straits fishery is also important.

Summer Chum – We hypothesize that small summer chum fry from the Dungeness and Elwha populations will encounter similar conditions as discussed in the fry migrant and delta fry Chinook sections, above. Marine vegetation is especially important to chum salmon because they leave estuarine regions for nearshore waters after a short period, and require adequate food supply such as copepods, as well as refuge opportunities. Many prey species are associated with marine vegetation such as eelgrass. Poor water quality in semi-enclosed embayments may impact this life history type (as discussed above). Also, removal of the two Elwha River dams is expected to benefit summer chum.

Bull Trout – The Strait of Juan de Fuca's estuaries and nearshore waters provides critical foraging, migration, and overwintering habitats for sub-adult and adult anadromous bull trout (USFWS 2004). In this region, these habitats are important for maintaining life history diversity and access to productive foraging regions (USFWS 2004). In addition to the Elwha and Dungeness core areas, bull trout have been shown to use other marine tributaries (e.g., Ennis Cr., Bell Cr., Morse Cr., and Siebert Cr.) for foraging and overwintering, possibly as "stepping stones" when moving through marine waters, as well as refuge from high water events (USFWS 2004). Poor water quality in semi-enclosed embayments may impact this life history type (as discussed above). Also, removal of the two Elwha River dams is expected to benefit bull trout.

All life history types in this sub-basin are at risk of non-support in the event of an oil spill since large volumes of crude oil are transported through this area to refineries at March Point and Cherry Point.

Table 6-6. Recommended Protection Actions for the Eastern Strait of Juan de Fuca

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect pocket estuaries and shallow water/low velocity habitats from further degradation near the deltas (w/in 5 miles), but skew this protection area to the east per oceanographic currents	Early marine support of all 4 life history types of Elwha and Dungeness Chinook populations (feeding and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	Support for neighboring Puget Sound populations (e.g., Hood Canal Chinook, larger juveniles from other populations, Fraser River populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	Support for neighboring Hood Canal summer chum, anadromous bull trout and other species. Functions addressed: feeding and growth, refuge, osmoregulatory, migration
Protect all feeder bluffs	Sustained migratory functions, riparian food source, refuge for Elwha and Dungeness populations	Sustained migratory functions, riparian food source, refuge for Hood Canal Chinook populations	Sustained migratory functions, riparian food source, refuge for Hood Canal summer chum populations; refuge, feeding and growth functions for anadromous bull trout
Protect against catastrophic events (oil spills)	Sustained feeding, growth, refuge, migration, osmoregulation for Elwha & Dungeness populations	Sustained feeding, migration and growth for Hood Canal Chinook, migration for other populations	Sustained feeding, growth, refuge, migration, osmoregulation for anadromous bull trout; feeding and migration for summer chum.
Protect functioning drift cells that support eelgrass bands and depositional features along the shoreline of Discovery Bay to Fort Worden (shoreline protection targets 19-23 in Fig. E-3.5), all west Whidbey Island shorelines within the sub-basin and between Port Angeles and Agnew (shoreline protection target 11).	Sustained feeding, growth and migration for Elwha and Dungeness populations	Sustained feeding, growth and migration of Hood Canal and other Puget Sound populations	Sustained feeding, growth and migration for summer chum, anadromous bull trout and other species.
Aggressively protect Eagle Creek, Paradise	Sustained feeding, growth, refuge and	Sustained feeding and growth for Hood Canal	Sustained feeding, growth, refuge and

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Cove and Bell Creek lagoon as properly functioning pocket estuaries within the sub-basin	osmoregulation for Elwha and Dungeness populations	and other populations	osmoregulation for anadromous bull trout; feeding and refuge for summer chum
Protect delivery of upland sediment sources to the nearshore from Shoreline protection targets 1a,b,c, 2,5,7, 10, 12-15 and 24 in Fig. E-3.5	Sustained feeding, growth, refuge and osmoregulation functions for Elwha and Dungeness populations	Sustained feeding, refuge and migration functions for all populations	Sustained feeding, growth, osmoregulation and refuge for anadromous bull trout; feeding, migration and refuge for summer chum and other species

Table 6-7. Recommended Improvement Actions for the Eastern Strait of Juan de Fuca

Improvement Action	Benefit to natal Chinook	Benefit to other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Consider and or continue (expand) wastewater reclamation and reuse retrofits for Port Townsend, Sequim (model for success) and Port Angeles wastewater discharges	Improved feeding and growth, osmoregulation functions for Elwha and Dungeness populations		
Restore pocket estuaries and shallow water/low velocity habitats near the deltas (w/in 5 miles), but skew this protection area to the east per oceanographic currents	Improved feeding, growth, osmoregulation and refuge functions for Elwha and Dungeness populations	Improved feeding, migratory and refuge functions for Hood Canal and other populations	Improved feeding, growth, osmoregulatory and refuge functions for anadromous bull trout; feeding and refuge, and migratory functions for summer chum and other species
Incorporate beach nourishment from Port Angeles landfill to Ediz Hook (special restoration target 8) as elements of the efforts to restore the Elwha delta and adjacent shoreline	Improved migratory feeding and refuge functions for Dungeness population	Improved migratory functions for all Puget Sound populations	Improved migratory, feeding and refuge functions for anadromous bull trout; migratory functions for summer chum and other species
Consider restoration of functions in Maynard, Blyn, Glenn Creek and Morse Creek pocket estuaries currently at risk of degradation	Improved feeding, growth, refuge and osmoregulatory functions for Elwha and Dungeness populations	Improved feeding and migratory functions for other Puget Sound populations	Improved feeding, growth, osmoregulatory and refuge functions for anadromous bull trout; feeding and migratory functions for summer chum and other species
Restore estuarine delta structure and functions as a result of Elwha dams removal and re-establishment of low elevation channel migration zones (Shoreline restoration target 7). This projects is regionally significant	Improves all functions for all life history types of Elwha population. Feeding, growth osmoregulation and refuge functions for Dungeness population fry migrants	Improves feeding, migration and refuge functions for all Puget Sound populations	Improves feeding, growth, osmoregulation functions for anadromous bull trout; feeding, migratory and refuge functions for summer chum and other species

6.4 San Juan Islands

A. Assessment

1. Salmon Use

Chinook

This is part of the South Georgia Straits and San Juan Islands regions, which includes independent populations in the Nooksack river system but none from the streams draining directly to this sub-basin.

a) Juvenile

- Juvenile Chinook salmon from multiple non-natal populations from all Geographic Regions of origin utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions) (See Figure 3-1 for a list of all Chinook populations).

b) Adult

- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a migratory corridor and foraging area.
- Adult salmon from far outside Puget Sound (e.g., Columbia River and Snake River ESU's) may utilize habitats within this sub-basin as a migratory corridor and foraging area.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. Non-natal use may occur, but it is not known for certain.
- Bull trout (anadromous): Preliminary core populations (from core areas) within the Puget Sound Management Unit of bull trout are not present in this sub-basin.

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

The San Juan Islands are unique in their location and as such, are an important corridor for adult fish from all populations. Forage fish and eelgrass are important components of the San Juan Islands' ecology. Forage fish require functioning nearshore habitats for spawning and rearing. Forage fish are critical prey items for salmon, as well as to marine mammals and birds.

In 2004, Friends of the San Juans produced a forage fish spawning habitat study report revealing forage fish spawning habitat regions within the archipelago. Four priority forage fish spawning habitat regions were identified: Mud/Hunter Bay region on Lopez Island; Westsound and Blind

Bay Region on Orcas and Shaw islands; Mackaye Harbor Region on Lopez Island; and Greater Westcott Bay Region on San Juan Island.

Landscape Conditions

Rocky shorelines dominate the San Juan Islands therefore, there is less perceived need for armoring. Protected shorelines of inner bays may be important for forage fish spawning because that is where the appropriate sediment grain sizes settle out. Wind and waves cause large vertical zonation of intertidal flora and fauna on some shorelines within the sub-basin.

Connectivity of habitats suitable for forage fish spawning is limited so the importance of support functions for rearing forage fish may be more important than spawning habitat here. Continuity of eelgrass and kelp beds are important to migrating juvenile and sub-adult salmon from all 22 populations of Chinook and the populations of Hood Canal/Eastern Strait of Juan de Fuca Summer chum. The importance of Haro Strait and other passes between the larger San Juan Islands as corridors for migrating adult salmon indicate an importance for Southern resident orca populations that rely on adult salmon for food.

See Figures E-3.1 through 3.3, E-4.4 and 4.5 in Appendix E for information about the landscape conditions in this sub-basin

Overall area

- Total area (deep-water plus nearshore) is 181,887 acres (284.2 square miles).
- Deep-water portion (marine waters landscape class) comprises 146,175 acres (228.4 square miles), or 80% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 35,776 acres (55.9 square miles), or 20% of the total sub-basin area. A natal estuary (landscape class) is not present in this sub-basin.
- Nearshore area within this sub-basin is 8% of the nearshore area of the entire Puget Sound basin.
- Contains 387 miles of shoreline (beaches landscape class).
- Numerous smaller bays can be found in the San Juan Island complex. Some of the bays (landscape class) identified in this sub-basin are Echo Bay, East Sound, West Sound, Deer Harbor, Blind Bay, Parks Bay, Burrows Bay, Mud Bay, Hunter Bay, Aleck Bay, Shoal Bay, Swifts Bay, Fishermans Bay, North Bay, Friday Harbor, Reid Harbor, Mitchell Bay, Westcott/Garrison Bay, False Bay, Roche Harbor, and Open Bay.
- Thirty-one linear miles (8%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 43% of the shoreline (168 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 29% of the shoreline (114 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 61% of the shoreline (238 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 29 pocket estuaries in this sub-basin spread throughout many of the larger islands.

- Freshwater sources were observed in over half the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in nearly all the pocket estuaries.
- Composite "scores" were generated for each pocket estuary based on likely Chinook functions and stressors observed during analyses. Sixteen pocket estuaries were estimated to be *properly functioning*. Two pocket estuaries were estimated to be *not properly functioning*. The remaining 11 pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

There are many small drift cells operating on soft sediment shorelines of the San Juan Islands between rocky beach areas. Many of the soft sediment depositional features in the islands also rely on upland sediment sources being delivered from small coastal streams. The drift cell characterization for this sub-basin and is presented in Figure E-4.5 and subsequent text in Appendix E. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of our recommendations for protection and restoration included in Tables 6-8 and 6-9.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Natal estuaries for Chinook salmon do not occur in this sub-basin. No information is presented for smaller, non-natal deltas and delta wetlands.

Alteration of flows through major rivers

Larger-scale flow alterations are not present in this sub-basin. Smaller dams and diversions likely exist but are not identified here.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

Shoreline armoring occurs along 17 miles (4%) of the shoreline (Fig. E-3.3). Over 12 miles of shoreline are classified as 100% armored; greater than 346 miles are classified as 0% armored. The total number of overwater structures in this sub-basin is 3,642, consisting of ramps (56), piers and docks (507), small slips (3,065) and large slips (14). Railroads do not occur in this sub-basin.

Contamination of nearshore and marine resources

The nearshore and marine waters of this sub-basin are in relatively good condition compared to other regions of Puget Sound, but the potential for contamination exists. Potential non-point sources of contamination identified in the San Juan County Watershed Management Action Plan (2000) include on-site septic systems, conversion of lands to residential and commercial development, stormwater runoff, agricultural practices, forestry practices, marinas and boating activities, and solid waste/hazardous waste. Of these, on-site septics, conversion of lands, and stormwater runoff were ranked as primary pollution sources. Location-specific pollution sources were specified in the report.

See Fig. E-3.3 in Appendix E for a depiction of water quality impairments in this sub-basin.

Alteration of biological populations and communities

Only one hatchery is found within the sub-basin and shellfish aquaculture operations are limited to small-scale oyster string culture operations in several embayments.

Transformation of land cover and hydrologic function of small marine discharges via urbanization

At this point, urbanization only seems to be negatively affecting one pocket estuary in any significant way and that is Roche Harbor on San Juan Island. See Figure E-4.4 in Appendix E for a list of this sub-basin's pocket estuaries and stressors noted in our review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp is not found here. Also, 44% of the shoreline (171 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin

a) Provide support (migratory corridor and foraging functions) for all neighboring Puget Sound populations (sub-adult and adult), as well as support for adult salmon from Columbia and Snake River ESU's.
a) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for sub-adult and adult Chinook.

b) Improve the knowledge of understanding of the diversity of life history type use in this sub-basin (i.e., it's not just juveniles, it's sub-adults and adults). Potential for large diversity (fish ranging in size from 60 to 150 mm (i.e., different age classes)).

Realized function for listed salmon and bull trout

Fry migrant Chinook – Only the easternmost shorelines of this sub-basin are within ten miles of natal deltas in the South Georgia Strait so few if any fry migrants are expected to use this sub-basin unless extreme flood events force small fish in that direction (Fig. E-3.2). In that event, low energy shorelines are available for rearing but few pocket estuaries are present.

Post-migrant young-of-year Chinook – Outmigrants from many populations could reach the San Juan Islands and find support by the diversity of landscape classes found there. For post-migrant juveniles, forage fish production becomes an important component of salmon survival. Competition with pink salmon for prey resources during even-numbered years may potentially impact Chinook salmon survival.

Sub-adult and adult Chinook – We hypothesize that the survival of sub-adult and adult Chinook salmon is greatly dependent on the production and availability of forage fish species within nearshore regions of this sub-basin. In addition, marine vegetation such as eelgrass and kelp also play an important role in salmon survival. As in the South Georgia Strait sub-basin during even-numbered years, competition with pink salmon for prey resources may impact Chinook salmon survival.

Summer Chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon do not use this sub-basin.

Bull Trout – We hypothesize that anadromous bull trout do not use this sub-basin

Table 6-8. Recommended protection actions for the San Juan Islands

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect diversity of habitats (e.g., eelgrass, kelp) important for sustaining forage fish species throughout their life history, not just spawning habitat		Sustained feeding and growth of juveniles, sub-adults, and adults of all populations	Sustained feeding, growth, migration functions for all species
Aggressively protect the 16 pocket estuaries designated in this analysis as properly functioning		Sustained feeding, refuge, migration and growth of juveniles, sub-adults, and adults of all populations	Sustained feeding, growth, migration functions for all species

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect against catastrophic events (many different populations use this sub-basin)		Sustained migration functions for all populations	Sustained migration functions for all species
Protect shoreline protection targets 1,2, 5, and 7-14		Sustained feeding function through forage fish production for all populations	Sustained feeding function through forage fish production for all species
Protect upland sediment sources within shoreline protection targets 3,4 and 6		Sustained feeding, refuge and migratory functions for all populations	Sustained feeding, refuge and migratory functions for all species

Table 6-9. Recommended improvement actions for the San Juan Islands

Improvement Action	Benefit to natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect juvenile salmon along shorelines by revisiting or revising the timing of in-water activities (e.g., construction, etc.) later in the calendar year (i.e., juvenile salmon are found to utilize nearshore regions later in the year than previously thought)		Improved growth, migration functions for all populations	Improved growth, migration for all species
Consider wastewater reclamation and reuse retrofits for Friday Harbor, Roche Harbor, Orcas and Rosario wastewater discharges		Improved feeding and refuge functions for all populations	Improved feeding and refuge for all species

6.5 Admiralty Inlet

A. Assessment

In this section we assess salmon and bull trout use, food web and ecological condition, landscape condition, and threats.

1. Salmon Use

Chinook

This is part of the Eastern Strait of Juan de Fuca and Admiralty Inlet region, which includes independent populations in the Dungeness and Elwha river systems but none from the streams draining directly to this sub-basin.

a) Juvenile
- All populations use this sub-basin, especially salmon populations from the main basin of Puget Sound (See Figure 3-1 for a list of all Chinook populations). This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles of all populations from all five Geographic Regions of origin.

b) Adult
- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a passage corridor and grazing area. Chinook are documented to use Gamble Creek and other regions in this sub-basin (See Fig. E-5.1). This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of sub-adults and adults of all populations from all five Geographic Regions of origin.
- Adult salmon from far outside Puget Sound (e.g., Columbia River and Snake River ESU's) may utilize habitats within this sub-basin as a migratory corridor and foraging area.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)
- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. Non-natal use by populations from Hood Canal/Eastern Strait of Juan de Fuca may occur, but it is not known for certain. Historically, summer chum used Chimacum Creek.
- Bull trout (anadromous): Preliminary core populations (from core areas) within the Puget Sound Management Unit of bull trout do not exist in this sub-basin. It is not known if populations from northern Hood Canal use this sub-basin as forging, migration or overwintering habitat.

2. Ecological and Landscape Conditions

<u>Food Web, Ecological Conditions</u>

Admiralty Inlet is the conduit through which southern populations of Chinook must pass through to reach the Strait of Juan de Fuca. Populations from the Whidbey Basin may also use Admiralty Inlet to reach the Strait of Juan de Fuca, in addition to using Deception Pass to the north. Admiralty Inlet is mostly an open water region with relatively extreme weather and beach action. Deep, dense, saline waters from the ocean and Strait of Juan de Fuca enter Admiralty Inlet and flow south to the Main Basin and north toward Possession Sound and the Whidbey Basin (Ebbesmeyer et al, 2002). Surface currents mostly exit Puget Sound through Admiralty Inlet and then out to the Strait (Ebbesmeyer et al, 2002). This sub-basin is an important place in the Sound where mixing between oxygen rich waters and outflowing surface waters occurs. Primary and secondary production depends on the right mix of nutrients, light and oxygen. Van Voorhis et al. (2002) reported a pattern of nutrient limitation near the end of summer snow melt, as well as during winter months.

Forage fish are an important component of the diet of outmigrating juveniles and sub-adults in this sub-basin. Pacific herring are found in Kilisut Harbor and the Port Gamble area, and sand lance and surf smelt spawning beaches are found in the same regions, as well as scattered along both east and west shores.

Admiralty Inlet is the major corridor for commercial and recreational vessel traffic in Puget Sound. The potential for oil spills and other contamination would potentially be catastrophic to many salmon populations using this sub-basin as a foraging and migratory corridor to and from the Strait of Juan de Fuca.

Landscape Conditions

In addition to large open water fetches that generate strong wave action, tidal currents are important in shaping nearshore features within this sub-basin. Tall sandy bluffs dominate the shorelines of Admiralty Inlet providing an ample sediment source for beaches, spits and shallow subtidal shelves.

Further depiction of landscape conditions is presented in Appendix E, Figures E-5.1 through E-5.5.

Pocket Estuary Analysis

Our visual analysis of pocket estuaries in this sub-basin revealed 29 pocket estuaries Most are within the southern edge of Port Townsend and Oak Bay/ Kilisut Harbor and the Port Ludlow region (see Fig. E-5.4). Among the results were:

- Freshwater sources were observed in just over one-half the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in 13 of the 29 pocket

Overall area

- Total area (deep-water plus nearshore) is 84,864 acres (132.6 square miles).
- Deep-water portion (marine waters landscape class) comprises 63,296 acres (98.9 square miles), or 75% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 21,568 acres (33.7 square miles), or 25% of the total sub-basin area. A natal estuary (landscape class) is not present in this sub-basin.
- Nearshore area within this sub-basin is 5% of the nearshore area of the entire Puget Sound basin.
- Contains 147 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Port Gamble, Port Ludlow, Mats Mats Bay, Oak Bay, Kilisut Harbor, and Port Townsend.
- Twenty-five linear miles (17%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 67% of the shoreline (99 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 11% of the shoreline (16 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 29% of the shoreline (43 linear miles) has non-floating kelp; may be patchy or continuous.

estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,

- Fifteen pocket estuaries were estimated to be *properly functioning*. Five pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

There are a number of large, relatively unarmored drift cells within Admiralty Inlet sub-basin. These are regionally important protection targets because of the length of shoreline they occupy and their current condition and function. The drift cell characterization developed for this sub-basin is presented in Appendix E, Figure E-5.5 and subsequent text. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of recommendations for protection and restoration included in Tables 6-10 and 6-11.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Natal estuaries for Chinook salmon do not occur in this sub-basin. No information is presented for smaller, non-natal deltas and delta wetlands.

Alteration of flows through major rivers

Larger-scale flow alterations are not present in this sub-basin. Smaller dams and diversions likely exist but are not identified here.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

Shoreline armoring occurs along 17 miles (13%) of the shoreline. Over 11 miles of shoreline are classified as 100% armored. Ninety-nine miles are classified as 0% armored. The total number of overwater structures in this sub-basin is 1,379, consisting of ramps (56), piers and docks (273), small slips (1,032) and large slips (18). Railroads occur along 0.1 miles of shoreline in this sub-basin.

Contamination of nearshore and marine resources

See Figure E-5.3 for a depiction of water quality impairments in this sub-basin.

Alteration of biological populations and communities

There are two fish hatcheries adjacent to this sub-basin. Shellfish aquaculture is distributed mainly within protected embayments like Kilisut Harbor, Oak Bay and Port Gamble.

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Seven pocket estuaries within the sub-basin are currently experiencing stress from urbanization to varying degrees including South Point, Port Ludlow and Chimacum Creek. See Figure E-5.4 for a list of pocket estuaries and noted stressors from visual observation via oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp is not found in this sub-basin. Also, 10% of the shoreline (14 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support independent spawning aggregations, including the Chinook documented to occur in Gamble Creek.

Goals for listed salmon and bull trout whos natal streams are outside this sub-basin

a) Provide support/use for all populations using this sub-basin, especially main basin Chinook populations. This area is a bottleneck, and for populations from the Stillaguamish, Snohomish and Skagit, this is the principle corridor to reach the Pacific Ocean via the Strait of Juan de Fuca. Fewer fish are thought to use Deception Pass as a corridor.
b) Chum salmon use of this area is not sufficiently known, although some historic use did occur in one stream approximately 20 years ago.
c) Fish in this sub-basin are not necessarily of small size; therefore the fish are not necessarily tied to shallow water habitats. Adequate water quality is critical to salmon in this sub-basin
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for sub-adult and adult Chinook.

Realized function for listed salmon and bull trout

Fry migrant and delta fry Chinook – More than 50% of the pocket estuaries support conditions favorable to this life history type, most of these situated on the western shores of Admiralty Inlet and along areas with protected shorelines (Figures E-5.1 and E-5.2), and many in areas near eelgrass (i.e., continuous bands). However, the pocket estuaries and nearshore habitats of this sub-basin are a great distance from natal estuaries of independent Chinook populations (much greater than 10 miles) and are likely only important for support of this life history type from local independent spawning aggregations.

The west side of Admiralty inlet (North Kitsap Peninsula) is more likely to support early migrant Hood Canal/Eastern Strait of Juan de Fuca Summer chum from Northern Hood Canal rivers and which may ultimately extend significantly south into the Central Puget Sound Sub-basin toward Kingston. The east side of Admiralty Inlet (West Whidbey Island) is more likely to support larger life history types of all populations of both Chinook and Hood Canal/Eastern Strait of Juan de Fuca Summer chum.

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. By the time Chinook and Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon are the size of parr migrants (approximately >70 mm), the Admiralty Inlet sub-basin is realized as a critical nexus in Puget Sound. Most of the 22 independent populations of Chinook salmon, and all the Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon must pass through Admiralty Inlet to reach the Strait of Juan de Fuca en route to the Pacific Ocean for maturation. Any type of catastrophic event (e.g., oil spill) would significantly affect most if not all ESA-listed salmon populations within Puget Sound. Guarding against such an event is a critical step to safeguarding populations as they emigrate to the Pacific Ocean.

In addition to being the main conduit for salmon populations, salmon the size of a parr migrant derives functions (e.g., rearing, foraging, refuge) from habitats within the nearshore. The west and south side of Admiralty Inlet contains most of the sub-basin's pocket estuaries (functioning, at risk and some not functioning), protected shorelines and eelgrass bands. Along the western shore, parr migrants coming from Hood Canal, Whidbey Basin and central and south sound must also contend with two sewage outfalls and a region of low dissolved oxygen near the Hood Canal Bridge and also in Port Gamble.

Yearling Chinook – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrant and possibly delta fry) within this sub-basin will negatively affect yearling migrants. As with the parr migrants, yearlings must also pass through Admiralty Inlet to the Strait of Juan de Fuca en route to the Pacific Ocean and any catastrophic event would be disastrous to salmon populations. Yearlings emigrating from Hood Canal, central and south sound, and the Whidbey Basin can derive function (e.g., foraging, refuge, migratory pathway) from the relatively unarmored shorelines with sparse overwater structure, as well as accessing the functioning (and at risk) pocket estuaries and protected shoreline regions.

Sub-adult and adult Chinook – We hypothesize that the survival of sub-adult and adult Chinook salmon is likely dependent on the production and availability of forage fish species within nearshore regions of this sub-basin. In addition, marine vegetation such as eelgrass and kelp play an important role in salmon survival. An uncontaminated migratory corridor is critical to survival of the majority of Chinook populations in Puget Sound that must pass through this region.

Summer Chum – Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon use the western shore of this sub-basin as outmigrant fry (Simenstad 2000a).

Bull Trout – We hypothesize that anadromous bull trout do not use this sub-basin

Table 6-10. Recommended protection actions for Admiralty Inlet

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Aggressively protect all drift cell function that supports eelgrass bands and depositional features throughout the sub-basin. Consider designating these shorelines for the highest level of protection within county shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines. (Shoreline protection targets 1-6, 8,9,11,13 on Fig. E-5.5, Appendix E)		Sustained feeding function through forage fish production for all populations	Sustained feeding function through forage fish production for all species
Protect against catastrophic events		Sustained migration functions for all populations	Sustained migration functions for all species

Table 6-11. Recommended improvement actions for Admiralty Inlet

Improvement Action	**Benefit to natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Restore drift cell functions in shoreline restoration targets 7,10,12 and 14 in Fig. E-5.5		Improved feeding function through forage fish production for all populations	Improved feeding function through forage fish production for all species

6.6 Whidbey Basin

1. Salmon Use

Chinook

This is part of the Whidbey Basin and Padilla and Samish bays region, which includes 10 of the 22 independent populations of Chinook within the Puget Sound ESU. Each of the independent populations in this region emanate from this sub-basin:

- Lower Skagit
- Upper Skagit
- Cascade
- North Fork Stillaguamish
- South Fork/Mainstem Stillaguamish
- Suiattle
- Lower Sauk
- Upper Sauk
- Skykomish
- Snoqualimie

a) Juvenile

- Juvenile Chinook salmon of all four life history types for all 10 natal populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon from neighboring populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor.

b) Adult

- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a migratory corridor and grazing area.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Natal populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not exist in this sub-basin. Non-natal use may occur, but it is not known for certain.

- Bull trout (anadromous): The Puget Sound Management Unit contains four core areas in this sub-basin (Snohomish/Skykomish, Stillaguamish, Upper Skagit, Lower Skagit). With the exception of the Upper Skagit core area, each core area is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound. In particular, the Lower Skagit core area is absolutely essential for this management unit. Bull trout from other basins are confirmed to use the Snohomish River estuary (USFWS 2004). Finally, the four core areas contain an estimated 33 local populations, greater than 3500 adult fish (estimated) and population trends varying from unknown to stable to increasing (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Whidbey basin and its nearshore environment is a unique region of Puget Sound. The Skagit, Snohomish and Stillaguamish are the three largest rivers in Puget Sound and all empty in the Whidbey Basin (Figure E-5.1), generating a strong surface outflow from Possession Sound (Ebbesmeyer et al, 2002). Of these rivers, the Skagit River is the largest source of freshwater flowing into Puget Sound. The depth of the density gradient in Possession Sound is close to the surface and well stratified (Van Voorhis et al, 2002), indicative of the large volume of freshwater flow into Whidbey Basin. A reduction of freshwater flow can affect the stratification. Portions of Whidbey basin are susceptible to low levels of D.O. (due in part to slower circulation and nutrient input) and poor water quality (e.g., lower Stillaguamish – West Pass). During low freshwater flows the water can heat up and the D.O. can decrease. Nutrient limitation can be pronounced in Possession Sound, and Van Voorhis et al, (2002) reported a pattern of nutrient limitation near the end of summer snowmelt.

Landscape Conditions

Because of the extreme influence of freshwater, the entire Whidbey Basin behaves like a giant estuary with all shorelines being affected by river discharge and sedimentation. Because the Snohomish and Stillaguamish are much older river deltas than the Skagit, the extent of tidal influence can be measured far upstream from the delta face and many important estuarine habitats are within distributary sloughs of the river channel, not in a deltaic fan offshore in the bay. The effect of strong southerly winds from the central basin and restricted tidal connection through Deception Pass coupled with the potentially high nutrient loads from the rivers, the waters of Whidbey Basin can become eutrophic.

See Figures E-5.1 through 5.3, E-6.4 and 6.5 in Appendix E for additional information about landscape conditions.

Overall area

- Total area (deep-water plus nearshore) is 157,631 acres (246.3 square miles).
- Deep-water portion (marine waters landscape class) comprises 80,128 acres (125.2 square miles), or 51% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 77,440 acres (121.0 square miles), or 49% of the total sub-basin area. As part of the nearshore, the Skagit, Stillaguamish and Snohomish estuaries are natal estuaries (landscape class) for the independent Chinook populations listed above, comprising 74.25 square miles (61%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 19% of the nearshore area of the entire Puget Sound basin.
- Contains 352 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Similk Bay, Dugula Bay, Crescent Harbor, Oak Harbor, Penn Cove, Holmes Harbor, Livingston Bay, Triangle Cove, and Tulalip Bay.
- Fifty-six linear miles (16%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 46% of the shoreline (162 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 2% of the shoreline (6 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 7% of the shoreline (24 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 17 pocket estuaries in this sub-basin: two in Skagit Bay, several scattered throughout Saratoga Passage, and several in Port Susan and Possession Sound.

- Freshwater sources were observed in nine of 17 pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in six of the 17 pocket estuaries,
- Two pocket estuaries were estimated to be *properly functioning*. Six pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

The complexity of Whidbey Basin shoreforms is as a result of a complex interplay between river sediments and longshore drift processes that affect steep sandy bluffs. The stability of these bluffs compared to Admiralty Inlet means that landslides or other mass wasting effects may be more important to add sediment to beaches than wave generated bluff erosion. The drift cell characterization for this sub-basin and is presented in Figure E-5.5 and subsequent text in Appendix E. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of recommendations for protection and restoration are included in Tables 6-10 and 6-11.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Skagit delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 6.18 to 4.63 square miles (decreased by 1.55 square miles). The estimated area of intertidal wetlands could not be calculated because historical estimates were not provided. In 1980, 21.24 square miles of intertidal wetlands were reported.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Stillaguamish delta, the estimate area of subaerial wetlands increased from historical to date of survey in 1980 from 1.15 to 1.39 square miles (increased by 0.24 square miles). The estimated area of intertidal wetlands could not be calculated because historical estimates were not provided. In 1980, 7.72 square miles of intertidal wetlands were reported.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Snohomish delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 15.06 to 3.86 square miles (decreased by 11.2 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 5.01 to 3.40 square miles (decreased by 1.61 square miles). The change in wetland habitat area between historical and current (1970's) condition in the Snohomish estuary is substantial. However, many of the agricultural lands made possible by historical diking are no longer actively worked. Thus, the Snohomish estuary offers significant opportunity for restoration.

Delta building (progradation) has occurred in the Stillaguamish River due to its quiet receiving waters, whereas in the Skagit and Snohomish delta, delta building has been less so because of the marine water's ability to move sediment from the delta front (Bortleson et al, 1980).

Historically, estuarine wetlands were extensive in the Skagit-Samish delta, consuming an area more than twice that of the Nooksack, Stillaguamish and Snohomish deltas, combined (Collins et al, 2003). Diking and draining of wetlands has reduced the area. The most extensive changes have occurred in the valley wetlands and loss of valley floor forests where most of the dense river bottom forests in Puget Sound have been eradicated (Collins et al, 2003). In a reconstruction analysis, Collins et al, (2003) showed the Stillaguamish River system was once similar to the Nisqually River (anastomosing pattern). Prior to extensive modification of the landscape by settlers, large floodplain wetlands and extensive estuarine marshes "accounted for nearly two-thirds (62%) of the valley bottom" of the Snohomish River (Collins et al, 2003). The removal of instream LWD has also impacted the Skagit, Snohomish and Stillaguamish river systems (Collins et al, 2003). The lower Snohomish and Stillaguamish River systems have been dramatically altered. In the Skagit River alone, between 1898 and 1908, 30,000 snags were removed (Collins et al, 2003).

Alteration of flows through major rivers

Three dams are located on the upper Skagit River, and are believed to be located in an area of a historical migration barrier (USFWS 2004). The flow regime downstream of Skagit River must adhere to Skagit Hydroelectric Project Fisheries Settlement Agreement (USFWS 2004). The three dams in the upper Skagit system have altered the transport of LWD to the lower river and Skagit estuary, resulting in reduced habitat complexity as compared to historical conditions (USFWS 2004).

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Skagit and Snohomish counties between 2000-2025 is 60% (61, 818 people) and 53% (323,290 people), respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along nearly 152 miles (44%) of the shoreline. One hundred forty four miles of shoreline are classified as 100% armored. Over 190 miles are classified as 0% armored. The total number of overwater structures is 5,046, consisting of ramps (169), piers and docks (369), small slips (4,390) and large slips (118). Overwater structure are observed intermittently throughout the sub-basin, and are concentrated in the Snohomish estuary (Everett region), and the LaConnor region. Within 300 feet of shore railroad grades occur along 3.8 miles, following the eastern shoreline from Mukilteo north to Everett. See the loss and/or simplification of deltas and delta wetlands piece (above) for a discussion on the loss of LWD.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface area are concentrated in the Marysville and Everett area, as well as Oak Harbor (PSAT 2004). In this sub-basin, Everett Harbor is one point source for contaminants such as from sewage and toxic contaminants (Washington Sea Grant, 2000). Potential non-point sources of contamination include stormwater runoff and failing septic systems (Washington Sea Grant, 2000). Surveys in 1996-1997 show depressed dissolved oxygen concentrations in Penn Cove (Washington Sea Grant, 2000), a region especially susceptible and sensitive to eutrophication (PSWQAT 2002a). The Skagit and Snohomish Rivers, comprising 47% of the Puget Sound Basin, contribute 50% of the nutrient loads (Embrey and Inkpen 1998). See the discussion in Ecological Conditions for more on water quality and dissolved oxygen.

Whidbey Basin is second only to central Sound in the degree of degraded sediments (PSAT 2002a). Chemical concentrations in Puget Sound sediments are typically greater in urban/industrialized regions, such as in Everett Harbor (PSAT 2002a). Nine percent of the area of this sub-basin exceeds the state's sediment quality standards and the cleanup screening levels.

Figure E-5.3 presents the distribution of water quality impairments across the sub-basin.

Alteration of biological populations and communities

The number of hatcheries operating in this sub-basin is 10. Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Shellfish aquaculture is not practiced in this sub-basin to any significant degree because of proximity to urban centers and potential bacterial contamination. A small shellfish aquaculture operation occurs within Triangle Cove.

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Warm Beach and Tulalip Bay are considered at risk for salmon functions largely due to impacts of urbanization. See Figure E-6.4 for a list of pocket estuaries and stressors noted in a review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Nine percent of the shoreline (33 miles) in this basin contains patchy or continuous *Spartina spp.*. Also, 4% of the shoreline (13 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) for the 10 independent populations of Chinook salmon emanating from this sub-basin,
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area.
c) Provide marine support for sub-adult and adult anadromous bull trout populations (approximately 33) within the four core areas in this sub-basin (Snohomish/Skykomish, Stillaguamish, Upper Skagit, Lower Skagit). The Lower Skagit core area is absolutely essential to sustaining the distribution of the anadromous bull trout life history trait within Puget Sound.
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, and bull trout.

e) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin

a) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults) that utilize nearshore and marine regions of this sub-basin as a migratory corridor.

Realized function for listed salmon and bull trout

Fry migrant Chinook – Fry migrants from each of the major rivers will be well supported by the abundance of low wave energy shorelines in this sub-basin, however, few pocket estuaries are currently available and most are in poor condition for supporting fry migrants (Figure E-5.2). This is more likely to affect this life history type during storm events. The frequent seasonal flooding of these systems is likely to disburse fry migrants widely throughout the sub-basin so it is expected that even pocket estuaries at some distance from the delta may serve natal functions during these events. Small streams embedded in shorelines may function as pocket estuaries. Any increase in armoring of residential shorelines is of concern for support of fry migrants. See Figure E-6.4 for a list of pocket estuaries and observed stressors. In addition, fry migrants may be impacted by the concentration of overwater structures in the Snohomish estuary and the LaConnor region.

Delta fry Chinook – The three large natal deltas within this sub-basin have the potential to produce large numbers of delta fry. The Snohomish delta has large amounts of potential habitat to support this life history type upstream of Everett because the tidal influence continues several miles inland. However, much of that potential habitat is locked up behind older industrial and agricultural infrastructure as well as ongoing uses. Considerable ongoing restoration within this delta is expected to greatly improve the support for delta fry. Delta fry in the Snohomish estuary, however, will be more exposed to poor water quality conditions in Everett Harbor due to contaminant loadings from toxics and sewage discharges (Figure E-5.3) than delta fry from the other two estuaries. Contaminated sediments and impaired invertebrate communities in Everett Harbor will likely impact this life history type. The Stillaguamish and Skagit deltas are greatly reduced in size compared to their historic condition, largely from agricultural diking. Delta fry support is likely to be a mere fraction of the historic condition. Only limited tidal restoration has occurred in these deltas and much more will be needed to significantly boost this important life history type.

Parr migrant Chinook – Parr migrants will be well supported by the large numbers of smaller life history types and forage fish within the sub-basin as a food source. Parr migrants from main basin populations also use the protected shorelines of this sub-basin for support. The density of fish in this sub-basin from these three deltas and neighboring sub-basins may suggest that competition is a factor in supporting this life history type.

In addition, poor water quality and contamination will likely impact this life history type. Low dissolved oxygen in the lower Stillaguamish, Penn Cove, and Possession Sound may pose a problem for this life history type as the fish are migrating throughout the sub-basin searching for forage. Contaminated sediments and impaired invertebrate communities in Everett Harbor may also impact this life history type.

Yearling Chinook – An abundance of forage fish and smaller life history types are available as a food source within this sub-basin so yearlings should be well supported. However, poor water quality and contamination may impact this life history type. Low dissolved oxygen in the lower Stillaguamish, Penn Cove, and Possession Sound may pose a problem for this life history type as the fish are migrating throughout the sub-basin searching for forage. Contaminated sediments and impaired invertebrate communities in Everett Harbor may impact this life history type.

Sub-adult and adult Chinook – We hypothesize the survival of sub-adult and adult Chinook salmon is likely dependent on several factors: the production and availability of forage fish species within nearshore regions, adequate water quality, low contamination levels and a healthy food chain, and the presence of marine vegetation, among others. Low dissolved oxygen levels and a reduction in prey, as well as contaminated food sources in the regions mentioned above have the potential to impact outmigrating sub-adults and returning adults.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon do not use this sub-basin.

Anadromous bull trout – The Snohomish/Skykomish, Stillaguamish, and Lower Skagit core areas are critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound (USFWS 2004). The Whidbey Basin's estuaries and nearshore waters provides critical foraging, migration, and overwintering habitats for sub-adult and adult anadromous bull trout. As in other sub-basins containing populations of anadromous bull trout, fish in this sub-basin feed on many prey items in productive shallow waters (USFWS 2004). As with yearling Chinook, and sub-adult and adult Chinook, bull trout may be impacted by poor water quality in estuarine and nearshore regions (e.g., Snohomish River, Penn Cove, Possession Sound), as well as contamination of sediments and prey items. Also, the loss of LWD in lower reaches of large rivers (e.g., Skagit), and estuaries, has reduced habitat complexity and can potentially impact bull trout.

All life history types in this sub-basin may be at risk from low dissolved oxygen from sewage discharges and poor oceanographic flushing.

This sub-basin is key to the viability of Chinook salmon and anadromous life forms of bull trout.

Table 6-12. Recommended protection actions for Whidbey Basin

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect all deltas, shorelines and pocket estuaries within the entire basin from further degradation, particularly all three natal deltas, Similik and Tosi Point pocket	Sustained early marine support of all 4 life history types of Skagit, Stillaguamish and Snohomish populations (feeding	Sustained support for neighboring Puget Sound populations (e.g., Lake Washington and Duwamish Chinook, larger	Sustained support for anadromous bull trout and other species. Functions addressed: feeding and growth, refuge,

estuaries and shoreline protection targets 3,5,6, 9-12 and 16 in Fig. E-6.5)	and growth, refuge, osmoregulatory, migration functions). Addresses all four VSP parameters	juveniles from other populations). Functions addressed: feeding and growth, refuge, osmoregulatory, migration	osmoregulatory, migration
Protect water quality within the sub-basin. There is the potential for dissolved oxygen problems/eutrophication due to excessive nutrient input (sewage outfalls, spills, agricultural). Prevent further degradation of D.O. and other water quality factors including avoidance of further stormwater loadings and NPDES discharge loadings	Sustained growth of all 4 life history types of Skagit, Stillaguamish and Snohomish populations.	Sustained migration functions for Lake Washington and Duwamish and other populations	Sustained growth of anadromous bull trout and other species.
Protect against catastrophic events	Sustained feeding, growth, osmoregulation, refuge and migration functions for all 3 natal populations	Sustained migration functions for all populations	Sustained migration functions for other species; feeding, growth, osmoregulation and refuge for anadromous bull trout
Ensure the amount of fresh water flowing into this sub-basin remains constant and does not drop to lower levels through added diversions, withdrawals, etc. A loss of freshwater may precipitate eutrophication and low DO in Possession Sound	Sustained growth of all 4 life history types of Skagit, Stillaguamish and Snohomish populations.	Sustained migration functions for Lake Washington and Duwamish and other populations	Sustained growth of anadromous bull trout and other species.

Table 6-13. Recommended improvement actions for Whidbey Basin

Improvement Action	**Benefit to natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Consider wastewater reclamation and reuse retrofits for all sewage discharge facilities within the sub-basin. Redirection of sewage treatment discharges to upland treatment and reuse/recharge systems will help to reduce summer time loadings that are degrading D.O. levels and shifting nearshore community structure.	Improved feeding, growth, and migration functions for all three natal populations	Improved feeding and migration functions for other populations	Improved feeding, growth and migration functions for anadromous bull trout and other fish species

Improvement Action	Benefit to natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Restore all three major deltas by removing agricultural levees and navigational structures that impede natural sediment and tidal processes in shoreline target areas 1,2,4 and 15 in Fig. E-6.5	Improved feeding, growth, refuge, osmoregulation and migration of all 4 life history types of all three natal populations	Improved feeding, growth, refuge and migration of other populations, especially Lake Washington and Duwamish	Improved feeding, growth, refuge, osmoregulation and migration of anadromous bull trout and other fish species
Restore all at risk pocket estuaries within the sub-basin, which includes Elger Bay, Triangle Cove, Livingston, Warm Beach, Tulalip Bay, Honeymoon Bay, Race Lagoon and Penn Cove	Improved feeding, growth, refuge, osmoregulation and migration of all 4 life history types of all three natal populations	Improved feeding, growth, refuge and migration of other populations, especially Lake Washington and Duwamish	Improved feeding, growth, refuge, osmoregulation and migration of anadromous bull trout and other fish species
Restore all shoreline restoration targets within the sub-basin (areas 7,8,13 and 14 in Fig. E-6.5)	Improved feeding and migration functions for all 3 natal populations	Improved feeding and migration for other populations	Improved feeding and migration for anadromous bull trout and other fish species
Re-create hydrologic connections of Skagit Bay to both Padilla Bay and Stillaguamish delta to restore access to South Georgia Straits/Padilla Bay/Whidbey sub-basins corridor for Chinook migrants from all populations originating in the Whidbey Basin and South Georgia Straits sub-basins	Improved migration functions for Snohomish, Stillaguamish and Skagit populations (addresses spatial structure and diversity VSP)	Improved migration for Duwamish, Lake Washington and Nooksack populations. (addresses spatial structure and diversity VSP)	Improved migration functions for anadromous bull trout and other fish species (addresses spatial structure and diversity VSP)
Conduct a prioritized cleanup of contaminated sediment hot spots and ongoing toxic discharges in the Everett Harbor area	Improve connectivity between the Snohomish delta and other landscape classes for sensitive life history types such as fry migrants		Improve connectivity between the Snohomish delta and other landscape classes for anadromous bull trout and other fish species

6.7 Hood Canal

1. Salmon Use

Chinook

This subbasin comprises the Hood Canal region, which includes two independent populations of Chinook:

- Skokomish
- Mid-Hood Canal

a) Juvenile

- Juvenile Chinook salmon of all four life history types from the Skokomish and mid-Hood Canal populations utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon from non-natal populations (e.g., Elwha and Dungeness) utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor.
- Chinook are documented in, and may spawn in, numerous other Hood Canal streams including Dewatto River, Big Beef Creek, and Lilliwaup Creek.

b) Adult

- Sub-adult and adult salmon from Puget Sound populations utilize habitats within this sub-basin as a migratory corridor and grazing area.
- Adult Chinook salmon from non-natal populations (specifically, Elwha and Dungeness populations) also utilize this sub-basin

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Six natal populations (Big and Little Quilcene, Dosewallips, Duckabush, Hamma Hamma, Lilliwaup and Union) of the Hood Canal/Eastern Strait of Juan de Fuca Summer chum ESU emanate from this sub-basin.
- Bull trout (anadromous): The Olympic Peninsula Management Unit contains one core area in this sub-basin (Skokomish), comprised of two populations. It is believed that anadromous bull trout may inhabit this core area. A larger region adjacent to the Skokomish drainage provides important foraging, migration, and overwintering habitat for sub adult and adult anadromous bull trout (USFWS 2004). Currently, the extent of the Skokomish population's use of this sub-basin is not known, but bull trout have been observed, historically, in several Hood Canal tributaries (e.g., Quilcene, Dosewallips, Duckabush, and Hamma Hamma River) (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Hood Canal is a long fjord with five major rivers contributing freshwater input, and contains a shallow east-west sill south of the Hood Canal Bridge, considerably more shallow than the areas immediately north or south of the sill (Fagergren et al, 2004). The natural geography of the region lends itself to an elevated natural sensitivity to nutrient input, due in part to slow flushing rates and the degree of stratification. As early as the 1950s, portions of Hood Canal experienced low dissolved oxygen levels, but since that time conditions have worsened (Fagergren et al, 2004). Persistent and worsening water quality problems, specifically low dissolved oxygen in the southern portion of Hood Canal continues to plague the ecosystem. Data from the 1990s revealed longer periods of time with biologically critical D.O. levels, hypoxic conditions, with low D.O. conditions possibly spreading to north Hood Canal (Fagergren et al, 2004). A pronounced and lengthy period of hypoxia in 2002 preceded a spring fish kill in 2003, followed by a widespread kill in the fall of 2003 (Fagergren et al, 2004). Dissolved oxygen levels during the winter of 2004 in south Hood Canal were the lowest on record (Fagergren et al, 2004).

The low D.O. conditions in Hood Canal may be a larger issue or problem for incoming adult salmon in the late summer or fall, rather than juvenile outmigrants because of the timing of hypoxic conditions. Forage fish, invertebrates like shrimp and octopus, rockfish and many other species are susceptible to mortality from hypoxia.

Harbor seal predation on returning adult salmon off the mouths of the Quilcene, Dosewallips, Duckabush, and Hamma Hamma river systems has been observed in 1998-2001. Seals were observed consuming summer chum, coho, and fall chum in all four years of observation. (VanBlaricom, et al, 2004) Additional surface observations were conducted in the fall of 2003 in order to assess the impact of an apparently large removal of seals by transient killer whales in Hood Canal during the winter of 2003. Although observations initially suggested major reductions in seal numbers, a more thorough evaluation of seal survey data suggests that the population-scale effect of the whale foraging event on harbor seals was small, and possibly even insignificant. This surprising result has led to reevaluation of broadly accepted assumptions about the metabolism and foraging ecology of transient killer whales, and suggests resilience of harbor seal populations to episodic attacks by predators. (VanBlaricom, et al, 2004)

Landscape Conditions

The shorelines of Hood Canal are a combination of low banks, sandy bluffs and rocky shorelines reflecting the complex geology of this fjord. The shorelines are punctuated by many stream and river mouths with broad deltaic fans, the largest of which is the Skokomish natal delta. The influence between these deltaic sediment sources and longshore sediment drift processes creates a shallow subtidal shelf in many areas that support extensive eelgrass patches. Between the patches is an almost continuous band of eelgrass along the steeper shorelines. A long history of Japanese oyster culture in Hood Canal resulted in the upper intertidal zone being almost completely colonized by living oysters or covered in empty oyster shells. The effect this cover has on the distribution of native plant and animal communities on beaches within Hood Canal is unknown.

The linkages between watersheds and natal and other estuaries are important to salmon as they move from freshwater to open marine waters (Simenstad 2000a). The estuaries, whether natal Chinook or summer chum estuaries, other estuaries with documented use by Chinook, summer chum, or bull trout, or pocket estuaries, are what Simenstad (2000a) refers to as "patches," dispersed along the shorelines of Hood Canal. The connection between all estuaries is important to summer chum and Chinook salmon. Summer chum salmon in this sub-basin are especially dependent on eelgrass beds (Simenstad 2000a).

See Figures E-7.1 through E-7.5 in Appendix E for additional information about landscape conditions in Hood Canal.

Overall area

- Total area (deep-water plus nearshore) is 85,888 acres (134.2 square miles).
- Deep-water portion (marine waters landscape class) comprises 62,784 acres (98.1 square miles), or 73% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 23,104 acres (36.1 square miles), or 27% of the total sub-basin area. As part of the nearshore, the Skokomish estuary is a natal estuary (landscape class) for the independent Chinook populations listed above, comprising 2.96 square miles (8%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 5% of the nearshore area of the entire Puget Sound basin.
- Contains 203 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Seabeck Bay, Stavis Bay, Dewatto Bay, Tahuya, Annas Bay, Lilliwaup Bay, Pleasant Harbor, Jackson Cove, Dabob Bay, Fishermans Harbor, Thorndike Bay, and Squamish Harbor.
- Fifty-eight linear miles (29%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 77% of the shoreline (156 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, floating kelp does not occur. In this sub-basin, 10% of the shoreline (21 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 39 pocket estuaries in this sub-basin. We analyzed these estuaries with Chinook salmon in mind: Using the Duckabush River as an approximate mid-point of this sub-basin, 15 pocket estuaries are located south of this point (most south of Hoodsport), and 24 are located north of the Duckabush River and relatively evenly distributed along both shorelines.

- Freshwater sources were observed in nearly three-quarters of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in 21 of the 39 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Eighteen pocket estuaries were estimated to be *properly functioning*. Seven pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

Several long stretches of shoreline in northern and eastern Hood Canal remain unarmored and are expected to have high natural function of drift cell processes. The southern and western shorelines are almost completely armored by single family residential and commercial property bulkheads. A drift cell characterization for this sub-basin is presented in Appendix E, Figure E-

7.5 and subsequent text. Littoral drift, feeder sources, deltaic processes, deposition, and recommendations for protection and restoration are discussed in Appendix E and highlights of recommendations for protection and restoration are included in Tables 6-14 and 6-15.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Skokomish delta, the estimated area of subaerial wetlands decreased from historical to date of survey in 1980 from 0.81 to 0.54 square miles (decreased by 0.27 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 1.93 to 1.73 square miles (decreased by 0.20 square miles).

Jay and Simenstad (1996) compared pre- and post-diversion surveys and suggested deposition has occurred on much of the inner delta and erosion on much of the outer delta. Many of the historical bathymetric change cross-sections revealed a steepening of the delta surface, apparently "caused by a loss of sediment transport capacity in the lower river and estuary combined with steady or increased (due to logging) sediment supply." In addition, a 15-19% loss of "highly productive low intertidal surface area" habitat between 0.6 m below MLLW and 0.6 m above was observed, as well as an estimated 17% decrease in area of eelgrass beds. A decrease in the amount of mesohaline mixing habitat was reported. Habitat losses in the Skokomish River basin are similar to those reported in other regions containing larger river basins experiencing water withdrawals of the same scale.

Alteration of flows through major rivers

Due to two dams on the Skokomish River, 40% of the annual average freshwater flow is diverted for power production and never reaches the delta (Jay and Simenstad 1996). Freshwater flow from the North Fork Skokomish River is mostly re-routed and does not contribute to mainstem flow contributions to the estuary (USFWS 2004). Sediment transport "is a critical link between fluvial alterations and the remote downstream, estuarine consequences thereof" (Jay and Simenstad 1996). Changes in habitat function and physical processes must be considered when evaluating estuarine effects of human-caused modifications.

Both dams have had lasting impacts on water quality and connectivity in the Skokomish River system and Hood Canal (USFWS 2004). Sediment transport capacity, available habitat, and channel capacity has been reduced, and flooding has become more frequent (USFWS 2004).

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Mason, Kitsap and Jefferson counties between 2000-2025 is 52% (25, 683 people), 43% (99,602 people), and 55% (14,508 people) respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along 63 miles (32%) of the shoreline. Over 40 miles of shoreline are classified as 100% armored. Over 107 miles are classified as 0%

armored. The total number of overwater structures is 1,448, consisting of ramps (159), piers and docks (264), small slips (1,017) and large slips (8). Overwater structure are concentrated in the southern most region of Hood Canal. Railroads are not present.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface area occur in Mason County near the terminus of Hood Canal, and sporadically along the western shoreline of Hood Canal north into Dabob Bay (PSAT 2004). In this sub-basin, nitrogen and organic material from various sources contribute to eutrophication, promoting excessive and rapid algal growth. Upon decomposition of algae, microorganisms can deplete the available oxygen in surrounding waters (Fagergren et al, 2004). Six primary categories of "human-influenced nitrogen sources" have been identified, totaling between 86 and 319 tons per year: Human sewage from onsite systems (39-241 tons); Stormwater runoff (12-24 tons, including lawn fertilizers); Chum salmon carcass disposal (16-24 tons); Agriculture – animal waste (18-22 tons); Forestry (0.5-5 tons); and Discharges from point sources (0.3-3 tons) (Fagergren et al, 2004).

Geographic source locations for each of the categories of nitrogen are as follows (from Fagergren et al, 2004): Human sewage (onsite systems) and stormwater runoff sources correspond to the populated regions of Hood Canal (Figure E-7.2). Chum salmon carcass deposition occurs primarily in the Skokomish River estuary. Agriculture (animal) waste occurs primarily in the Skokomish and Union watersheds. Fertilization in forestry practices occur in the southern half of Hood Canal on private forestlands, as well as on USFS lands throughout the sub-basin. Discharges from point sources occur in various forms and are located throughout Hood Canal. The 303D points are concentrated in the area from Union to Belfair; general industrial sources are concentrated in the Belfair region and Quilcene Bay, and a few other locations spread around the Canal.

Alteration of biological populations and communities

Nine hatcheries operate in this sub-basin (State, Federal, Tribal) as well as 12 small private salmon production operations (USFWS 2004).

Transformation of land cover and hydrologic function of small marine discharges via urbanization

Figure E-7.4 provides a list of pocket estuaries and stressors noted from review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp are not found in this sub-basin. However, 45% of the shoreline (92 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types (fry migrants, delta fry, parr migrants, yearlings) of the Skokomish Chinook salmon population emanating from this sub-basin. Provide early marine support for Chinook populations emanating from other estuaries (e.g., Dosewallips, Duckabush, Hamma Hamma, and others – See list in 1 a) and b))
b) Provide support for sub-adult and adult Chinook salmon populations utilizing habitats within this sub-basin as a migratory corridor and grazing area.
c) Provide early marine support for the six Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon populations emanating from this sub-basin
d) Provide marine support for sub-adult and adult anadromous bull trout populations within the Skokomish core area in this sub-basin
e) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, Hood Canal/Eastern Strait of Juan de Fuca Summer chum, and bull trout.
f) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams area outside this sub-basin

a) Provide for some non-natal Chinook use: Elwha and Dungeness fish are known to use this sub-basin.
b) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults) that utilize nearshore and marine regions of this sub-basin as a migratory corridor.

Realized function for listed salmon and bull trout

Fry migrant Chinook – Fry migrants from the Skokomish independent Chinook salmon population can derive function from the mostly low wave energy shorelines and nine pocket estuaries within five and ten miles of the Skokomish natal estuary (Figure E-7.2). Many of the pocket estuaries provide the opportunity to rear, osmoregulate and seek refuge in the shallow water, low-velocity habitats, however nearly half of these pocket estuaries are also at risk of losing this ability due to the presence of stressors (see Figure E-7.4). The majority of properly functioning pocket estuaries occur well outside and to the north of the 10-mile buffer of the Skokomish delta. Again, connectivity between habitat types and landscape classes, including intact freshwater “lenses” (or bands) along shorelines, is essential for small-sized fry migrants emerging from the Skokomish delta in search of rearing and refuge locations, and satisfying osmoregulatory requirements.

In addition, water quality (dissolved oxygen), water quantity (Cushman dam) and shoreline armoring/development are three factors that have the potential to impact the fry migrant's ability to emigrate to desired habitats outside the Skokomish estuary.

Delta fry Chinook – The net loss of intertidal wetlands within the Skokomish delta from historic conditions is relatively small (0.27 mi^2 or 124 acres) (Bortleson et al., 1980). Consequently, the opportunity for Chinook salmon delta fry to access delta habitat is available, and scheduled to improve with the advent of some dike removal to expose additional delta habitat. The Skokomish estuary has the potential to produce large numbers of Chinook salmon delta fry, as well as Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon (discussed below). Reversing the persistent poor water quality conditions in south Hood Canal (e.g., dissolved oxygen) is a key step to salmon recovery in this sub-basin. The water quantity issues and shoreline armoring/development described above also impact this life history type. Connectivity of habitat types and landscape classes is again, critical to delta fry.

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. The opportunity exists for parr migrants from the Skokomish Chinook salmon population, and from populations in other estuaries (e.g., Hamma Hamma, Duckabush, Dosewallips) as well as Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon to derive function from habitats nested within shorelines. The numerous bays and eelgrass bands in this sub-basin may provide a valuable resource to this life history type as they emigrate north toward the Strait of Juan de Fuca.

Yearling Chinook – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrants) within this sub-basin will negatively affect yearling migrants. Connectivity between habitat types and landscape classes is very important to yearlings from the Skokomish Chinook salmon population and the Hood Canal/Eastern Strait of Juan de Fuca Summer chum populations (discussed below), as well as other populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the other sections above. Yearling migrants can derive functions (e.g., foraging, refuge, migratory pathway) from available nearshore habitats as described above. Of particular concern is the poor water quality plaguing this sub-basin, and while outmigrating yearlings may be less impacted than returning adults (or sub-adults) due to the timing of low D.O. events, this life history type is nonetheless at risk of ever increasing D.O. problems.

Sub-adult and adult Chinook – Sub-adult, and especially adult Chinook are likely to face an increasing problem when returning to Hood Canal to spawn in freshwater systems in the fall. This time of year corresponds annually to the lowest D.O. levels in southern Hood Canal, and as mentioned in earlier sections, the spatial and temporal trends are increasing northward and occurring earlier in the year. Other factors related to depressed D.O. conditions, and potentially impacting sub-adults and returning adults focus on the food web: available prey items, contaminated food chain, among others.

Listed summer chum – Six natal populations emanate from this sub-basin. As young fry in Hood Canal, summer chum remain close to shore in shallow surface waters while rearing in estuarine habitats, but after a short period of time larger fish can move offshore into open marine waters, even crossing Hood Canal (Simenstad 2000a). Smaller estuaries other than the natal estuaries listed in 1 b) are important to juvenile chum, termed subestuaries by Simenstad (2000a), but pocket estuaries in this analysis. These estuaries, or "patches" occur at irregular intervals along the shoreline of Hood Canal, and some of these can be viewed in Figure E-7.4. Eelgrass is very important as habitat for juvenile summer chum and it is probable that eelgrass is the principal migratory corridor linking estuaries at the estuarine landscape in Hood Canal (Simenstad 2000a). Interruption of contiguous migratory corridors, in this case eelgrass bands, may negatively impact juvenile chum salmon. Several activities contribute to this interruption, including armoring, diking, and overwater structures.

Dabob Bay is thought to be especially important summer chum salmon, and the central and northern regions of Hood Canal yield the majority of pocket estuaries. Returning adult chum salmon will most likely experience similar issues with the depressed D.O. levels, as do adult Chinook.

We refer the reader to the Hood Canal/Eastern Strait of Juan de Fuca Summer chum recovery plans at **http://www.wa.gov/hccc/about.htm** and **http://wdfw.wa.gov/fish/chum/chum-5b.htm** for more information.

Anadromous Bull Trout – The bull trout population from the Skokomish is depressed and at risk of extirpation as a result of reduced numbers and fragmentation (USFWS 2004). Due to the Skokomish dams, the altered sediment size and patterns has increased erosion on the outer delta and increased deposition on the inner edge of the delta (USFWS 2004). As a result, the biological productivity of the intertidal zone within the estuary has been reduced, as has the eelgrass area of which herring require for spawning (USFWS 2004). Herring are an important prey item for bull trout, and because of the issues described above, foraging opportunities have been reduced in the Skokomish estuary (USFWS 2004). Furthermore, the dams on the Skokomish River have had effects that have reduced the available spawning and rearing habitat (USFWS 2004).

Table 6-14. Recommended protection actions for Hood Canal

Protection Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Aggressive protect areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of the Skokomish delta (and the deltas of the composite populations from the Dosewallips, Duckabush and Hamma Hamma).	Sustained feeding, growth, refuge, osmoregulation and migration functions for Skokomish and composite central Hood Canal populations	Sustained feeding, refuge and migration functions for other populations	Sustained feeding, growth, refuge, osmoregulation functions for summer chum and anadromous bull trout and other species
Protect small freshwater tributary regions	Sustained feeding, osmoregulation and refuge functions for Hood Canal populations	Sustained feeding, osmoregulation and refuge functions for other Puget Sound populations	Sustained feeding, osmoregulation and refuge functions for summer chum and anadromous bull trout
Protect against catastrophic events	Sustained feeding, growth and migration functions for Hood Canal populations	Sustained migration functions for other populations	Sustained feeding, growth and migration functions for summer chum and anadromous bull trout
Aggressively protect functioning drift cells and feeder bluffs that support eelgrass bands and depositional features along the entire eastern shoreline and the western shoreline north of Point Whitney, including Dabob and Quilcene bays. Counties should designate these shorelines for the highest level of protection within shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines and offering landowner incentives for protection.	Sustained feeding, growth, refuge and migration functions for Hood Canal populations	Sustained feeding, growth, refuge and migration functions for other populations	Sustained feeding, growth, refuge and migration functions for summer chum and anadromous bull trout

Table 6-15. Recommended improvement actions for Hood Canal

Improvement Action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Achieve and maintain adequate dissolved oxygen levels, including avoidance of further stormwater loadings and NPDES discharge loadings. Consider wastewater reclamation and reuse retrofits for all sewage discharges from wastewater plants into lower Hood Canal	Decreased risk of hypoxia-induced mortality	Decreased risk of hypoxia-induced mortality	Decreased risk of hypoxia-induced mortality
Aggressively promote shellfish environmental codes of practice	Improved feeding, refuge and migration functions for Hood Canal populations	Improved feeding, refuge and migration functions for other populations	Improved feeding, refuge and migration functions for summer chum and anadromous bull trout
Restore the Skokomish River delta by removing dikes, insuring adequate overbank flooding within the floodplain and adequate freshwater inflow from the watershed	Improved feeding, growth, refuge, osmoregulation and migration functions for Skokomish and composite central Hood Canal populations	Improved feeding, refuge and migration functions for other populations	Improved feeding, growth, refuge, osmoregulation functions for summer chum and anadromous bull trout and other species
Aggressive restore areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of the Skokomish delta (and the deltas of the composite populations from the Dosewallips, Duckabush and Hamma Hamma)	Improved feeding, growth, refuge, osmoregulation and migration functions for Skokomish and composite central Hood Canal populations	Improved feeding, refuge and migration functions for other populations	Improved feeding, growth, refuge, osmoregulation functions for summer chum and anadromous bull trout and other species
Increase tidal prism and estuarine connectivity (i.e., all distributaries) at all Highway 101 river crossings to benefit natal and non-natal populations of Chinook and Hood Canal/Eastern Strait of Juan de Fuca Summer chum salmon.	Improved feeding, growth, refuge, osmoregulation and migration functions for Skokomish and composite central Hood Canal populations	Improved feeding, refuge and migration functions for other populations	Improved feeding, growth, refuge, osmoregulation functions for summer chum and anadromous bull trout and other species

6.8 Central Puget Sound

In this section we assess salmon and bull trout use, food web and ecological conditions, landscape conditions, and threats.

1. Salmon Use

Chinook

This is part of the Central and South Puget Sound Region which includes six independent populations of Chinook. Five of these populations emanate from this sub-basin:

- Lake Washington
- Cedar
- Green
- White
- Puyallup

This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles, sub adults, and adults of many populations from almost all geographic regions of origin.

a) Juvenile

- Juvenile Chinook salmon from each of the five natal populations, as well as non-natal populations from throughout Puget Sound, utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- Juvenile Chinook salmon primarily use the Green, Puyallup and Lake Washington areas as a migratory corridor – a link from upper watersheds to Puget Sound.
- Non-natal populations likely derive some function from the smaller freshwater tributaries within this basin.

b) Adult

- Sub-adult and adult salmon from the five natal populations utilize habitats within this sub-basin as a migratory corridor and grazing area.
- Adult Chinook salmon from non-natal populations also utilize this sub-basin

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Natal populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not exist in this sub-basin. Non-natal use may occur, but it is not known for certain. Non-natal use by early migrant chum salmon from Northern Hood Canal Rivers may extend south into this sub-basin (i.e., Kingston area).
- Bull trout (anadromous): The Puget Sound Management Unit contains two preliminary core areas (Puyallup, Chester Morse) in this sub-basin. The Puyallup watershed is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound because it is the only main watershed in south Puget Sound supporting this life history type. This core area contains an estimated 5 local populations, less than 1000

> adult fish (estimated) and an unknown population trend (population numbers generally low) (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

The Central Puget Sound sub-basin is the most industrialized and populated sub-basin in Puget Sound. The three main natal Chinook estuaries on the eastern shore of this region, Puyallup River at Commencement Bay, Duwamish River at Elliot Bay, and "Salmon Bay" at Shilshole Bay draining Lake Washington, are highly developed. Many of the smaller estuaries and pocket estuaries, as well as shorelines are also developed to varying degrees. As a result, populations of Chinook (and particular life history types) have been impacted more so than populations from other sub-basins.

Portions of this sub-basin exhibit poor water quality, and if not addressed or corrected, may continue to negatively affect the ecology of this sub-basin. Toxic contaminants such as PCBs and PBDEs (and others) are polluting the food web of Puget Sound, particularly the central and south sound basins (three sub-basins: central Puget Sound, Carr-Nisqually, south Puget Sound). Natal Chinook salmon populations from the two basins as well as a primary salmon prey (i.e., Pacific herring) appear to be contaminated with toxics (see following sections for more detail). These "resident" salmon (i.e., natal populations) exhibit greater concentrations of toxics when compared to migratory salmon (i.e., non-natal populations) passing through each sub-basin.

Quartermaster Harbor supports forage fish (e.g., herring) spawning functions, and forage fish are an important prey resource for natal and non-natal salmon populations. A recent oil spill in the Dalcos Passage region spread to Quartermaster Harbor.

Landscape Conditions

The Central Puget Sound sub-basin is the most industrialized and populated sub-basin in Puget Sound, yet it still maintains a fairly high level of ecological function within some ecosystem components. Below are excerpts from the Executive Summary of King County's State of the Nearshore Report for Water Resource Inventory Areas 8 and 9, which make up the bulk of the main basin of Puget Sound.

> Eelgrass forms small patches to large meadows in the low intertidal and shallow subtidal zone of Puget Sound, covering about 57 percent of the shoreline of WRIA 8 and 62 percent of WRIA 9. Kelps occur in small patches to large forests throughout the study area, covering 12 percent of the shoreline in WRIA 8 and 7 percent of WRIA 9, including 6.4 percent within Elliott Bay. Six percent of the shoreline in WRIA 8 and 29.7 percent of the shoreline in WRIA 9 is composed of flats as defined by the ShoreZone database, which does not include lower tidal flats. Over the past century, 97 percent of the shallows and flats in the Duwamish estuary and Elliott Bay have been lost due to dredge and fill operations for urban and industrial development. Although the entire delta was filled in, much of the subsequent shoreline armoring is present in the upper intertidal

> zone, and gently sloping mud and sandflats exist in the lower intertidal and subtidal zones. Shoreline armoring, dredging, and filling have probably caused loss of flats in other parts of the study area, as well. Historical filling, diking, armoring, and other human intrusions have eliminated all but a few small tidal marshes in the study area. Dramatic reductions occurred in the Duwamish estuary, where over 1,170 acres of tidal mash was eliminated early in the century. The largest remaining tidal marsh system in WRIAs 8 and 9 is Kellogg Island, within the Duwamish estuary. Most of the shoreline of Puget Sound is composed of gravel, cobble, sand, or silt beaches. Beaches are generally distinguished from flats by their steeper grade, but generally support similar functions. Puget Sound beaches often transition to sandflats at about MLLW. Similar to the use of flats, juvenile salmonids rely on beach environments for foraging and refuge before migrating to deeper water. Adult bull trout and cutthroat trout also forage seasonally in shallow beach habitats at high tides. Beaches and backshore areas can be highly productive; shellfish production is commonly very high on cobble and gravel beaches where deposition includes organic matter. (King County DNR, 2001).

Figures E-8.1 through E-8.5 in Appendix E depict additional information about the landscape condition in central Puget Sound.

Overall area

- Total area (deep-water plus nearshore) is 192,511 acres (300.8 square miles)
- Deep-water portion (marine waters landscape class) comprises 158,655 acres (247.9 square miles), or 82% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 33,856 acres (52.9 square miles), or 18% of the total sub-basin area. As part of the nearshore, the Puyallup, Duwamish and "Salmon Bay" deltas are natal deltas for the independent Chinook populations listed above, comprising 3.22 square miles (6%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 8% of the nearshore area of the entire Puget Sound basin.
- Contains 308 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Shilshole Bay, Elliot Bay, Commencement Bay, Gig Harbor, Quartermaster Harbor, Clam Bay, Blakely Harbor, Eagle Harbor, Murden Cove, Port Madison, Miller Bay, Appletree Cove, and Cultus Bay.
- Sixty-six linear miles (21%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 50% of the shoreline (154 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 10% of the shoreline (32 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 23% of the shoreline (71 linear miles) has non-floating kelp; may be patchy or continuous.

Pocket Estuary Analysis

We identified 37 pocket estuaries in this sub-basin: most of these are located on the western shorelines of this sub-basin; only a few are located on the east shore of the basin and most of these are north of Edmonds.

- Freshwater sources were observed in nearly two-thirds of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated were estimated to occur in 12 of the 37 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Fifteen pocket estuaries were estimated to be *properly functioning*. Four pocket estuaries were estimated to be *not properly functioning*. The remaining 18 pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

A drift cell characterization developed for this sub-basin is presented in Appendix E, Figure E-8.5 and subsequent text. Highlights of recommendations for protection and restoration are included in Tables 6-16 and 6-17.

Threats/stressors

For a detailed listing of threats and stressors identified for Central Puget Sound, refer to King County's State of the Nearshore Report, 2001.
http://dnr.metrokc.gov/wlr/watersheds/puget/nearshore/sonr.htm

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Duwamish delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 1.0 to 0.01 square miles (decreased by 0.99 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 3.28 to nearly 0 square miles (decreased by as much as 3.28 square miles). Extensive dredge and fill operations have resulting in a nearly 100% loss of intertidal wetlands from historic conditions in the Duwamish delta is nearly 2,100 acres.

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Puyallup delta, the estimate area of subaerial wetlands decreased from historical to date of survey in 1980 from 3.86 to nearly 0 square miles (decreased by as much as 3.86 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 2.86 to 0.04 square miles (decreased by 2.82 square miles). Extensive dredge and fill operations have resulting in a 98% loss of intertidal wetlands (1,804 acres) from historic conditions in the Puyallup delta.

Alteration of flows through major rivers

In the Green/Duwamish River drainage a re-distribution of flows has occurred. Prior to 1900, several rivers drained nearly 1600 square miles before forming the Duwamish River and ultimately emptying into Elliot Bay (King County, 2002). By 1916, the drainage network was substantially altered, with three rivers re-routed from the Green/Duwamish system and a nearly one-third reduction in the total drainage area (King County, 2002) (Figure 4-6). In addition, a diversion dam and flood control dam blocking upstream fish passage was erected on the upper Green River and a hatchery opened on the same river in 1901-02. The lower Green/Duwamish River was dredged, channelized, shortened and straightened to better facilitate navigation (King County, 2002).

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in King, Snohomish, and Pierce counties between 2000-2025 is 20% (355,356 people), 53% (323,290 people), and 34% (241,337 people) respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along nearly 179 miles (58%) of the shoreline. Over 136 miles of shoreline are classified as 100% armored. Eighty-seven miles are classified as 0% armored. The total number of overwater structures is 10,448, consisting of ramps (251), piers and docks (838), small slips (9,032) and large slips (327). Overwater structure are observed in greater concentrations in Commencement Bay and Tacoma, Duwamish waterway and Elliot Bay. These structures are also evident along much of the eastern shoreline of the sub-basin, as well as Vashon and Maury Island, eastern half of Bainbridge Island, and part of Colvos Passage. Within 300 feet of shore railroad grades occur along 18.9 miles, following the shoreline in the Tacoma area, and from Ballard north to Mukilteo.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface are found along most of the eastern shore of this sub-basin (PSAT 2004).

Sediment samples analyzed from 1997-1999 reveal the central Puget Sound region to have the greatest degree of degraded sediments (PSWQAT 2002a). Chemical concentrations in Puget Sound sediments are typically greater in urban/industrialized regions, such as in Elliot Bay and Commencement Bay (PSWQAT 2002a). 4.6 percent of the area of central Puget Sound is contaminated about state sediment quality standards and 2.6% of the area exceeds the cleanup screening levels.

See Figure E-8.3 for a depiction of the distribution of water quality impairments in central Puget Sound.

Alteration of biological populations and communities

Pacific herring have been found to be "3 to 11 times more contaminated with PCBs in central and south Puget Sound than the Strait of Georgia" (WDFW, unpublished data). These WDFW results from 2004 are similar to those reported in 1999 and 2000 in PSWQAT (2002a), where body burdens of PCBs were higher in Pacific herring from the central basin (Port Orchard) and southern Puget Sound basin (Squaxin Pass) than Pacific herring from northern Puget Sound and the Strait of Georgia.

There are approximately 30 hatcheries releasing various species of salmonids into the main basin of Puget Sound, the highest concentration of hatcheries of any sub-basin. This may affect community structure at certain times of the year, especially if hatchery releases are not appropriately timed to avoid over-utilization of available prey resources or predation of wild fish. Because of poor water quality, there are no commercial shellfish aquaculture operations in the Main Basin, however, there are several floating net pen aquaculture facilities. Overharvest of fisheries species in the past, continued recreational fishing pressure, loss of critical habitats and poor water quality have potentially greatly altered biological populations and communities within the main basin but comparative studies with other sub-basins in Puget Sound have not been conducted.

Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine drainages via urbanization

In many cases, the historic pocket estuaries of the main basin have been completely filled or drained for development. The University of Washington River History Project in cooperation with Washington Department of Natural Resources and the Puget Sound Nearshore Ecosystem Restoration Project, is conducting an analysis of central Puget Sound shorelines using historical maps and data sets to ascertain how many small marine discharges and their associated marsh and mudflat features may have been lost in the Main Basin over the last 150 years. .

Figure E-8.4 lists of pocket estuaries we identified in central Puget Sound and evaluates the stressors on these pocket estuaries based on our review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

One percent of the shoreline (4 miles) contains *Spartina spp*; may be patchy or continuous. 26% of the shoreline (81 miles) contains *Sargassum muticum*; may be patchy or continuous. Because of the proximity of these shorelines to developed urban and suburban areas, the presence of invasive escaped garden plants is high even in relatively undisturbed parkland. Scotch broom, English ivy and Japanese knotweed are particularly abundant along shoreline parks and forested residential properties.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for life history types of the independent Chinook populations emanating from this sub-basin,
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area,
c) Provide marine support for sub-adult and adult anadromous bull trout populations (5) within the two core areas in this sub-basin (Puyallup, Chester Morse).
d) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, and bull trout.
e) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin.

a) Provide support for all neighboring Puget Sound populations (juveniles, sub-adults, and adults) that utilize nearshore and marine regions of this sub-basin as a migratory corridor.
b) Provide support functions in the northern portion of this sub-basin for early migrant Hood Canal/Eastern Strait of Juan de Fuca Summer Chum, if used.

Realized function for listed salmon and bull trout

Fry migrant Chinook – Independent populations of Chinook salmon from the Green, Puyallup and Lake Washington are at very high risk. Only five pocket estuaries are identified along the extensively armored and expansive, highly urbanized eastern shoreline of this sub-basin (Figure E-8.2 in Appendix E). Just two of the pocket estuaries are estimated to be properly functioning. The remaining pocket estuaries are located on the western shoreline of this sub-basin, opposite the three highly developed natal deltas supporting five independent populations of Chinook salmon. Therefore, there is little opportunity or capacity to access or utilize any shallow water, low-velocity habitats along the same shoreline as the natal deltas. Instead, the small fish may need to traverse across the open waters to access shallow, low velocity areas and pocket estuaries on the western shoreline. There are shallow, protected shorelines within reach of Central Sound rivers where small Chinook can be found along Bainbridge Island shorelines in the spring. While these habitats are within five or ten miles of each natal estuary (Figure E-8.2), it is not known if remnant fry migrant life history types readily exploit habitats on western shores.

In addition, available fry migrants must contend with a host of issues, each affecting the ability to access and derive function from suitable habitats (i.e., connectivity between natal deltas and landscape classes and habitat types). For example, water quantity (reduced due to dams, diversions, developed stream mouths; reduction/loss of seeps and groundwater recharge), water quality (elevated temperature and reduced dissolved oxygen), pollution (chemicals and wastewater discharges [Figure E-8.3], and elevated body burdens of toxic contaminants such as PCBs and PBDEs in salmon within this sub-basin [WDFW, unpublished data]) and physical attributes (extensively armored eastern shoreline [bulkheads, railroads], clearing and grading of marine riparian vegetation). It is not known if restoration activities would benefit this marginally existent life history type.

Delta fry Chinook – The natal estuaries have been substantially altered from historic conditions. Consequently, the opportunity and capacity for delta fry to utilize habitats within the three estuaries is nearly eliminated. Connectivity between habitat types within the estuary/shorelines and landscape classes is essential for small-sized delta fry emigrating distances to and within this sub-basin. Furthermore, the conditions and stressors described above in the fry migrant section also impact any remnant natal delta fry.

Simenstad (2000) discussed the ability of Commencement Bay and the Puyallup delta habitats to support juvenile salmon. His assessment shows that present-day delta habitats are smaller, extremely fragmented with little or no connectivity, and with numerous stressors impacting the region. Puyallup River freshwater contributions still exist, but lateral water movement within the delta, as well delivery of sediments and organic materials, is not occurring. River flow and sediment contributions fail to extend out into the Bay very far, and therefore sediments cannot adequately replenish nearshore, intertidal and/or shallow subtidal habitats. As a result, the utilization of habitats by one or more of the four life history types is limited. There is little opportunity for delta fry, for example, to derive important rearing and physiological transition functions from the Puyallup delta because these fish, and all juvenile salmon, are thrust into the Commencement Bay and forced to osmoregulate in higher salinities (brackish) than if allowed to osmoregulate in the preferred shallow water, low-velocity regions typical of other estuaries (e.g., Nisqually). It should be noted that juvenile salmon (such as delta fry) are capable of exploiting any shallow water, low-velocity regions, and in fact continue to do so wherever available in the Puyallup delta. Finally, restoration opportunities do exist in this highly urbanized delta (e.g., diversion of some Puyallup River flow through Hylebos waterway to encourage build up of delta).

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. Parr migrants in this sub-basin also include a lake rearing type from Lake Washington. The opportunity exists for larger-sized parr migrants from natal Chinook populations, as well as non-natal populations from throughout Puget Sound to utilize shallow water, low-velocity habitats within the nearshore (e.g., estuaries, pocket estuaries and shorelines), of primarily the western shorelines of this sub-basin. Numerous *properly functioning* (and *at risk*) pocket estuaries are located on Bainbridge, Vashon and Maury Islands, characterized by much less armoring than the eastern shoreline. Non-natal parr migrants moving north from the southern sub-basins, and south out of the Whidbey sub-basin can utilize these nearshore habitats. In addition, juveniles from the Hood Canal/Eastern Strait of Juan de Fuca Summer chum ESU may frequent and utilize habitats within the northern section of this sub-basin. This is not known for certain.

As discussed in the above sections, numerous conditions and stressors affect the natal estuaries, other estuaries, and eastern shoreline of the sub-basin. These also impact natal and non-natal parr migrants moving throughout the Central Sound sub-basin. Connectivity between habitat types and landscape classes is essential to this life history type. Any type of catastrophic event (e.g., oil spill) would likely affect many of the ESA-listed salmon populations within Puget Sound. Guarding against such an event is a critical step to safeguarding populations as they emigrate to the Pacific Ocean.

Yearling Chinook – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrants) within this sub-basin will negatively affect yearling migrants. Connectivity between habitat types and landscape classes is also important to yearlings from the three natal populations, and other populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the other sections above. Yearling migrants can derive functions (e.g., foraging, refuge, migratory pathway) from available nearshore habitats as described above. Of special concern are the toxic contaminants polluting the food web in the three southern sub-basins and the body burden effects on salmon. In addition, the forage fish population in Quartermaster Harbor is an important prey species for natal and non-natal yearling life history types, as well as to the smaller-sized juvenile salmon (e.g., parr migrants).

Sub-adult and adult Chinook – Larger fish migrating through this sub-basin must contend with several issues, including toxic contaminants in the food chain, sediment contamination in several urban estuaries, and the potential for oil spills. Researchers from WDFW have documented that, in general, Chinook salmon living in or migrating through Puget Sound (specifically in central and south sound) are more contaminated with PCBs than stocks outside of Puget Sound (e.g., Columbia River, WA coast). See Figure 4.7 in Section 4. Residence time in the central and southern Puget Sound basins is suspected as a “primary predictor of PCB concentration in Chinook salmon” and as such, those salmon spending the greatest amount of time in central and south sound exhibit the greatest PCB concentrations (WDFW, unpublished data) (Figure 4-8). Another toxic contaminant of concern in Puget Sound is PBDEs, a common chemical that, like PCBs, are found in greater concentrations in resident Chinook salmon versus migratory Chinook salmon.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon may use the northern portion of this sub-basin, but to what degree is not known.

Anadromous bull trout – Of the two core areas, the Puyallup watershed is critical for sustaining the distribution of the anadromous bull trout life history trait within Puget Sound because it is the only main watershed in south Puget Sound supporting this life history type, and is the southernmost population of bull trout (USFWS 2004). Anadromous bull trout use the Puyallup and White River, and are thought to use habitats in Commencement Bay and other nearshore shorelines (USFWS 2004). Extensive development in the Commencement Bay region is likely impacting bull trout. Furthermore, as with yearling Chinook, and sub-adult and adult Chinook, bull trout may be impacted by contamination of sediments and prey items. Also, the loss of LWD in lower reaches of large rivers and estuaries may have reduced habitat complexity.

Table 6-16. Recommended protection actions for central Puget Sound

Protection action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect smaller freshwater tributaries	Sustained feeding, growth, osmoregulation and refuge functions	Sustained feeding, growth and refuge functions	Sustained feeding, growth, osmoregulation and refuge functions for anadromous bull trout, summer chum and other species
Protect water quality, especially temperature and dissolved oxygen– must ensure appropriate levels of each are available to any and all life history types utilizing this sub-basin.	Sustained growth and reduced mortality	Sustained growth and reduced mortality	Sustained growth and reduced mortality of anadromous bull trout, summer chum and other species
Protect the forage fish spawning areas in Quartermaster Harbor	Sustained feeding function	Sustained feeding function	Sustained feeding function for anadromous bull trout and other species
Protect all remaining functional shoreline features on Vashon-Maury Island from further degradation. The relative importance of low levels of shoreline development in this heavily armored sub-basin cannot be overestimated.	Sustained feeding, growth, refuge, migration functions, especially for Puyallup and Duwamish populations	Sustained feeding, growth, refuge, migration functions	Sustained feeding, growth, refuge, migration functions for anadromous bull trout and other species
Protect functioning drift cells, feeder bluffs for their role in supporting eelgrass bands and depositional features along Colvos Passage, Maury Island, Narrows and the shoreline from Kingston to Foulweather Bluff. (Shoreline Protection Target Areas 2, 4, 5, 10, 11, 13, 15, 18, 21, 22 in Figure E-8.5). Designate these shorelines for the highest level of protection within shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines and support landowner incentive programs for conservation.	Sustained feeding, growth, refuge, migration functions	Sustained feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Sustained feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Protect against catastrophic events	Sustained growth and migration functions	Sustained growth and migration functions	Sustained growth and migration functions

Table 6-17. Recommended improvement actions for central Puget Sound

Improvement action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Add enhanced treatment for stormwater discharging directly to Puget Sound to the same standards as for salmon bearing streams.	Improved growth and reduced mortality	Improved growth and reduced mortality	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Consider wastewater reclamation and reuse retrofits for all wastewater discharges into the sub-basin, especially new discharges.	Improved growth and reduced mortality	Improved growth and reduced mortality	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Complete and implement plans for diverting some Puyallup River flow through the Hylebos to enhance delta structure and processes.	Improved feeding, growth, osmoregulation and refuge functions	Improved feeding, growth and refuge functions, especially for Nisqually population	Improved feeding, growth, osmoregulation and refuge functions for anadromous bull trout and other species
Restore smaller freshwater tributaries.	Improved feeding, growth, osmoregulation and refuge functions	Improved feeding, growth and refuge functions	Improved feeding, growth, osmoregulation and refuge functions for anadromous bull trout, summer chum and other species
Prioritize and implement cleanups of sediment contaminant hot spots and ongoing toxic discharges	Improved growth and reduced mortality via bioaccumulation in the food chain	Improved growth and reduced mortality via bioaccumulation in the food chain	Improved growth and reduced mortality of anadromous bull trout, summer chum and other species
Restore connections between uplands and shorelines by retrofitting Burlington Northern/Santa Fe railroad grade from Golden Gardens to Mukilteo for improved access to blocked pocket estuaries).	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Conduct limited beach nourishment on a periodic basis to mimic the natural sediment transport processes in select sections where corridor functions may be impaired by extensive armoring (Shoreline Restoration Target Areas 12,16, 17, 20,23 in Fig. E-8.5) and seaward of the railroad grade from Golden Gardens to Mukilteo.	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Encourage voluntary re-vegetation of cleared residential shorelines from Alki Point to Brown Point.	Improved feeding, growth, refuge, migration functions	Improved feeding, growth, refuge, migration functions for populations from all neighboring sub-basins	Improved feeding, growth, refuge, migration functions for anadromous bull trout, summer chum and other species
Reform hatchery practices	Improved feeding, growth and survival	Improved feeding and growth	Improved feeding and growth of anadromous bull trout and summer chum

6.9 Port Madison/Sinclair Inlet

A. Assessment

In this section we assess salmon and bull trout use, food web and ecological condition, landscape condition, and threats.

1. Salmon Use

Chinook

This is part of the Central and South Sound region, which includes six independent populations in the Cedar-Lake Washington, Green, Puyallup, and Nisqually river systems but none from the streams draining directly to this sub-basin.

a) Juvenile

- Juvenile Chinook salmon from neighboring populations (e.g., central Puget Sound sub-basin) utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions). See Figure 3-1 for a list of all Chinook populations. This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles of many populations from all five geographic regions of origin, but is likely most importantly for populations from the geographic region it lies within, and adjacent geographic regions of origin.

b) Adult

- Sub-adult and adult salmon from neighboring populations utilize habitats within this sub-basin as a passage corridor and grazing area. This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of sub adults of many populations from all five geographic regions of origin, but is likely most importantly for populations from the geographic region it lies within, and adjacent geographic regions of origin.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: Populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU do not emanate from this sub-basin. It is not known if these populations use this sub-basin
- Bull trout (anadromous): Preliminary core populations within the Puget Sound Management Unit of bull trout do not exist in this sub-basin. It is not known if any anadromous bull trout use this sub-basin.

2. Ecological and Landscape Conditions

<u>Food Web, Ecological Conditions</u>

The Port Madison/Sinclair Inlet sub-basin contains industrialized regions in Dyes Inlet and Sinclair Inlet, and some of the region is experiencing rapid growth. Port Madison supports a herring stock and Dyes Inlet supports a smaller stock, both important prey resource for non-natal Chinook populations.

Overall area

- Total area (deep-water plus nearshore) is 17,728 acres (27.7 square miles), the smallest of all 11 sub-basins
- Deep-water portion (marine waters landscape class) comprises 4,416 acres (6.9 square miles), or 25% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 13,376 acres (20.9 square miles), or 75% of the total sub-basin area.
- Nearshore area within this sub-basin is 3% of the nearshore area of the entire Puget Sound basin.
- Contains 96 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin is Liberty Bay, Fletcher Bay, Dyes Inlet, and Sinclair Inlet.
- Fifteen linear miles (16%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 16% of the shoreline (15 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, floating kelp does not occur. In this sub-basin, 18% of the shoreline (17 linear miles) has non-floating kelp; may be patchy or continuous.

Landscape Conditions

Landscape conditions for this sub-basin are depicted in Figures E-8.1 through 8.3 and E-9.4 of Appendix E.

Pocket Estuary Analysis

We identified 39 pocket estuaries in this sub-basin. This sub-basin contains the greatest concentration of pocket estuaries in Puget Sound (1.86 per square mile). Seventeen of the 39 pocket estuaries are located in the Dyes Inlet region, with the remaining pocket estuaries distributed across the landscape in a relatively even distribution.

- Freshwater sources were observed in greater than two-thirds of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated to occur in 24 of the 39 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Six pocket estuaries were estimated to be *properly functioning*. Seven pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

The drift cell characterization developed for this sub-basin is presented in Appendix E, Figure E-8.5 (Main Basin) and subsequent text. Recommendations for protection and restoration are highlighted in Tables 6-18 and 6-19.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Natal estuaries for Chinook salmon do not occur in this sub-basin. No information is presented for smaller, non-natal deltas and delta wetlands.

Alteration of flows through major rivers

Larger-scale flow alterations are not present in this sub-basin. Smaller dams and diversions likely exist but are not identified here.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Kitsap County between 2000-2025 is 43% (99, 602 people) (PSAT 2004). In this sub-basin, shoreline armoring occurs along 56 miles (59%) of the shoreline. Over 31 miles of shoreline are classified as 100% armored. Over 17 miles are classified as 0% armored. The total number of overwater structures is 2,383, consisting of ramps (98), piers and docks (256), small slips (1,936) and large slips (93). Overwater structures are observed in greater concentrations where armoring occurs. Within 300 feet of shore railroad grades occur along 2.6 miles, along a section of heavily armored shoreline in the southern portion of Sinclair Inlet.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface are concentrated in Dyes Inlet and Sinclair Inlet, as well as Liberty Bay (PSAT 2004). Sediment samples analyzed from 1997-1999 reveal the majority of observed sediment contamination was located in urban waters such as Sinclair Inlet (PSWQAT 2002a). Over all years for which samples were collected and analyzed, Sinclair Inlet had higher levels of metals (copper, lead, mercury, silver, zinc) than any other location sampled in Puget Sound.

Figure E-8.3 illustrates the distribution of water quality impairments in this sub-basin.

Alteration of biological populations and communities

Stations sampled as part of the Ecology/NOAA 1997-1999 evaluation of sediment quality exhibited impaired invertebrate communities in Sinclair Inlet and Dyes Inlet (PSWQAT 2002a).

There are approximately 8 hatcheries releasing various species of salmonids into the Port Madison/Sinclair Inlet sub-basin, which may affect community structure at certain times of the year. Because of poor water quality, there are no commercial shellfish aquaculture operations in the sub-basin, however, there are several floating net pen aquaculture facilities. Overharvest of fisheries species in the past, continued recreational fishing pressure, loss of critical habitats and poor water quality have potentially greatly altered biological populations and communities within the sub-basin but comparative studies with other sub-basins in Puget Sound have not been conducted. Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine drainages via urbanization

Despite the small size of this sub-basin, we identified more pocket estuaries here than in the entire main basin of Puget Sound. Only 5 of the 39 pocket estuaries analyzed were determined to not be properly functioning for juvenile Chinook, largely due to urbanization impacts. Seven additional pocket estuaries are at risk of losing significant functions due to urbanization and many shoreline areas and watersheds are still rapidly urbanizing within the sub-basin. See Figure E-9.4 – list of pocket estuaries and noted stressors from visual observation via oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp is not found in this sub-basin. 9% of the shoreline (9 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

<u>Goals for listed salmon and bull trout whose natal streams are in this sub-basin</u>

a) Provide early marine support for independent spawning aggregations, such as fish from streams such as Gorst Creek.

<u>Goals for listed salmon and bull trout whose natal streams are outside this sub-basin</u>

a) Provide support for all neighboring Puget Sound Chinook salmon populations.
b) Maintain and/or increase forage fish production as prey for non-natal salmon populations
c) Provide spatial structure and diversity support for populations of Chinook salmon from within the main basin (e.g., central Puget Sound sub-basin).

Realized function for listed salmon and bull trout

Fry migrant Chinook – Some of the fish emanating from streams such as Gorst Creek may adopt this life history strategy and rely on shallow, protected habitats in the vicinity of their natal estuaries. Two-thirds of the pocket estuaries in this sub-basin are estimated to be "at risk" by one or more landscape stressors, though the opportunity exists to derive some function (feeding and growth, refuge, and/or physiological transition) from many of the pocket estuaries in this sub-basin should fry migrants from this or other sub-basins (e.g., central sound) reach the shoreline habitats (Figure E-9.2). The density of pocket estuaries in this sub-basin may contribute little to the viability of fry migrant Chinook in the Puget Sound ESU because the nearest independent populations are (1) fairly distant from this sub-basin's pocket estuary resources, and (2) not currently expressing significant fry migrant (or delta fry) trajectories.

Delta fry Chinook – Natal estuaries for independent populations of Chinook salmon are not present in this sub-basin. Delta fry may occur in fish emanating from streams such as Gorst Creek, but these small natal estuaries probably to not provide much habitat capacity.

Parr migrant Chinook – On average this life history type is the most abundant in Puget Sound. Parr migrants and yearlings from neighboring sub-basins are most likely to utilize available nearshore habitats of this sub-basin because these fish are larger and capable of surviving greater swimming distances from the natal estuaries in central and south Puget Sound. Connectivity between habitat types and landscape classes is critical to ensure successful exploitation of available habitats. Parr migrants will encounter heavily armored shorelines, at risk or not properly functioning pocket estuaries, sewage outfalls and chemical contamination throughout much of Sinclair Inlet. Conditions are similar, but improved slightly in Dye Inlet with the exception of some areas with depressed dissolved oxygen levels. Parr migrants will encounter generally improved conditions moving north through Port Orchard with the exception of Liberty Bay where temperature, chemicals and low dissolved oxygen are evident (Figure E-9.3). Finally, the Port Madison herring stock is an important forage fish for parr migrants.

Yearling Chinook –Connectivity between habitat types and landscape classes is very important to yearlings from central sound populations, and other populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the parr migrant section above. Yearling migrants can derive functions (e.g., foraging, refuge, migratory pathway) from available nearshore habitats. Forage fish from the Port Madison herring stock will be especially important to this life history type as yearlings from multiple Chinook populations migrate throughout Puget Sound.

Sub-adult and adult Chinook – Larger fish migrating through this sub-basin may need to contend with issues such as toxic contaminants in the food chain and sediment contamination. Researchers from WDFW have documented that, in general, Chinook salmon living in or migrating through Puget Sound (specifically in central and south sound) are more contaminated with PCBs than stocks outside of Puget Sound (e.g., Columbia River, WA coast). See Figure 4.7 in Section 4. Residence time in the central and southern Puget Sound basins is suspected as a "primary predictor of PCB concentration in Chinook salmon" and as such, those salmon spending the greatest amount of time in central and south sound exhibit the greatest PCB concentrations (WDFW, unpublished data) (Figure 4-8). Another toxic contaminant of concern in Puget Sound is PBDEs, a common chemical that, like PCBs, are found in greater concentrations in resident Chinook salmon versus migratory Chinook salmon.

Listed summer chum – We hypothesize that Hood Canal/Eastern Strait of Juan de Fuca summer chum salmon do not use this sub-basin.

Anadromous bull trout – We hypothesize that anadromous bull trout do not use this sub-basin.

Table 6-18. Recommended protection actions for Port Madison/Sinclair Inlet

Protection action	**Benefit to Natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Aggressively protect all pocket estuaries regardless of their current function or proximity to natal deltas within the central Puget Sound sub-basin. (See Fig. E-9.4)	Support for weakly swimming migrants from systems such as Gorst Creek	Sustained feeding, growth, refuge and migration functions for all Puget Sound populations, especially from main Basin and Hood Canal	Sustained feeding, growth, refuge and migration functions other species
Protect water quality from further degradation	Support for small, sensitive fish from systems such as Gorst Creek	Sustained migration and reduced mortality for PS populations	Sustained migration and reduced mortality for other species
Protect against catastrophic events		Sustained migration and reduced mortality for PS populations	Sustained migration and reduced mortality for other species
Protect Port Madison (and the smaller Dyes Inlet) herring stock, as well as forage fish spawning grounds		Sustained feeding and growth for PS populations	Sustained feeding and growth for other species

Table 6-19. Recommended improvement actions for Port Madison/Sinclair Inlet

Improvement action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Consider wastewater reclamation and reuse for all current and planned new sewage discharges throughout the sub-basin	Improved support for small, sensitive fish from independent spawning aggregations (eg., Gorst Creek)	Improved migration and reduced mortality for PS populations	Improved migration and reduced mortality for other species
Add enhanced treatment for stormwater discharging directly to Puget Sound to the same standards as for salmon bearing streams	Improved support for small, sensitive fish from systems such as Gorst Creek	Improved migration and reduced mortality for PS populations	Improved migration and reduced mortality for other species
Encourage voluntary re-vegetation of cleared residential shorelines throughout the sub-basin. Put special emphasis on maintaining connectivity, primary production and water quality		Improved feeding, growth, refuge and migration functions for all Puget Sound populations, especially from main Basin and Hood Canal	Improved feeding, growth, refuge and migration functions other species
Restore drift cell function in Shoreline Restoration Target Area 9 (Main Basin Map Fig. E-8.5)		Improved feeding, growth, refuge and migration functions for all Puget Sound populations, especially from main Basin and Hood Canal	Improved feeding, growth, refuge and migration functions other species
Restore areas containing contaminated sediment hot spots and ongoing toxic discharges.		Improved migration and reduced mortality for PS populations	Improved migration and reduced mortality for other species
Reform hatchery practices		Improved feeding and growth	Improved feeding and growth of other species

6.10 Carr/Nisqually

1. Salmon Use

Chinook

This is part of the Central and South Sound region, which includes six independent populations in the Cedar-Lake Washington, Green, Puyallup, and Nisqually river systems. The Nisqually population emanates from this sub-basin.

a) Juvenile

- Juvenile Chinook salmon of all four life history types from the Nisqually natal population utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions).
- This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles of many populations from almost all geographic regions of origin.
- Populations from south Puget Sound, particularly fish from the central Puget Sound sub-basin where most delta functions have been lost, also utilize this sub-basin for feeding and growth, refuge, physiological transition and as a migratory corridor.

b) Adult

- Adult Chinook salmon from the Nisqually natal population derive functions (i.e., feeding, migratory corridor) from this sub-basin. See Figure E-10.1 for map of other Chinook use besides the Nisqually River.
- Adult Chinook salmon from non-natal populations also utilize this sub-basin
- This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of sub adults and adults of many populations from almost all geographic regions of origin.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: None of the eight populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU targeted for recovery emanate from this sub-basin. However, summer chum populations within the ESU are documented to exist in this sub-basin in Chambers Creek and Burley Creek.
- Bull trout (anadromous): Preliminary core populations within the Puget Sound Management Unit of bull trout do not emanate from this sub-basin. However, the upper and lower Nisqually River is considered important foraging, migration, and overwintering habitat for recovering populations from the north (USFWS 2004).

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Portions of this sub-basin exhibit poor water quality, and if not addressed or corrected, may continue to negatively affect the ecology of this sub-basin. As in the Central Puget Sound sub-basin, toxic contaminants such as PCBs and PBDEs (and others) are polluting the food web of

Puget Sound, particularly the central and south sound basins (three sub-basins: central Puget Sound, Carr-Nisqually, south Puget Sound). Natal Chinook salmon populations from the two basins as well as a primary salmon prey (i.e., Pacific herring) appear to be contaminated with toxics (see following sections for more detail). These "resident" salmon (i.e., natal populations) exhibit greater concentrations of toxics when compared to migratory salmon (i.e., non-natal populations) passing through each sub-basin.

A comprehensive approach toward restoration of the historical water quantity, nutrients, and water quality baseline pathways and patterns will likely be necessary to protect and restore ecological functions to conditions supporting viable populations in protected sub-basins with limited circulation, such as this sub-basin. Preventing further degradation of D.O. and other water quality factors including avoidance of further stormwater loadings and NPDES discharge loadings will be key. Beyond that, redirection of sewage treatment discharges to upland treatment and reuse/recharge systems will be needed to reduce summer time loadings that are degrading D.O. levels and shifting nearshore community structure (Bill Graeber, NOAA-TRT, pers. comm.).

Re-creation of the Nisqually Delta estuary represents a riverine estuary restoration potential of regional significance. Restoring the Nisqually Delta estuary represents one of only a few opportunities to recover an increment of the 70% historic loss of this habitat type in a block large enough to be a fully functional river estuary and to restore ecologic processes at the regional scale. Watershed efforts already underway on restoration of the estuary should be fully supported and further encouraged (Bill Graeber, NOAA-TRT, pers. comm.)

Landscape Conditions

The Carr-Nisqually sub-basin lies inland of a significant underwater geologic sill and tidal constriction through the Tacoma Narrows. This effects the sub-basin and neighboring South Sound sub-basin in several ways. Extreme tidal ranges can be up to 18 feet, nearly twice as large as the Strait of Juan de Fuca and San Juan Islands because of tidal pumping through the Narrows. The sill also isolates the waters of Carr-Nisqually and South Sound sub-basins so that the oceanographic residence time is considerably longer than the main basin leading to a susceptibility for nutrient pollutants to concentrate over time leading to eutrophication.

Figures E-10.1 through E-10.5 in Appendix E provide additional information about landscape conditions in this sub-basin.

Pocket Estuary Analysis

We identified 35 pocket estuaries in this sub-basin. This sub-basin contains a high concentration of pocket estuaries in Puget Sound (1.35 per square mile). The many pocket estuaries are distributed relatively uniformly throughout the sub-basin.

- Freshwater sources were observed in fewer than half (15) of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated were estimated to occur in 13 of the

Overall area

- Total area (deep-water plus nearshore) is 51,136 acres (79.9 square miles)
- Deep-water portion (marine waters landscape class) comprises 34,688 acres (54.2 square miles), or 68% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 16,448 acres (25.7 square miles), or 32% of the total sub-basin area. As part of the nearshore, the Nisqually estuary is a natal estuary (landscape class) for the independent Chinook population listed above, comprising 4.15 square miles (16%) of the total nearshore area within this sub-basin.
- Nearshore area within this sub-basin is 4% of the nearshore area of the entire Puget Sound basin.
- Contains 156 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin are Chambers Bay, Taylor Bay, Oro Bay, Amsterdam Bay, Filuce Bay, Henderson Bay, Wallochet Bay, and Horsehead Bay.
- Forty-four linear miles (28%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 34% of the shoreline (53 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, 4% of the shoreline (7 linear miles) has floating kelp; may be patchy or continuous. Also in this sub-basin, 4% of the shoreline (6 linear miles) has non-floating kelp; may be patchy or continuous.
- 35 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Nineteen pocket estuaries were estimated to be *properly functioning*. Five pocket estuaries were estimated to be *not properly functioning*. The remaining 11 pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

The drift cell characterization developed for this sub-basin is presented in Appendix E, Figure E-10.5 and subsequent text. Recommendations for protection and restoration are highlighted in Tables 6-20 and 6-21.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Comparison of historical wetland area and wetland area reported in Bortleson et al. (1980) revealed that for the Nisqually delta, the estimated area of subaerial wetlands decreased from historical to date of survey in 1980 from 2.20 to 1.58 square miles (decreased by 0.62 square miles). The estimated area of intertidal wetlands decreased from historical to date of survey in 1980 from 2.85 to 2.24 square miles (decreased by 0.61 square miles). The loss of lowland wetlands has not been as pronounced as in other larger estuaries to the north, and is much less developed than other large, natal estuaries. Diking for agriculture purposes is the primary reason for any loss, but in recent years some dikes have been breached (or removed) to allow for increased tidal inundation and exchange. This is expected to greatly benefit salmon and bull trout.

Alteration of flows through major rivers

Two dams occur on the Nisqually River, Alder dam and LaGrande dam. A natural barrier on the river is thought to have occurred in the location of LaGrande dam (USFWS 2004). Other large-scale flow alterations are not present in this sub-basin. Smaller dams and diversions likely exist but are not identified here. Diking is present in the lower river and estuary.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Pierce and Thurston counties between 2000-2025 is 34% (241,337 people) and 62% (129,470 people), respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along nearly 68 miles (44%) of the shoreline. Thirty-three miles of shoreline are classified as 100% armored. Over 53 miles are classified as 0% armored. The total number of overwater structures is 1,588, consisting of ramps (177), piers and docks (346), small slips (1,058) and large slips (7). Overwater structures generally overlap with the shoreline armoring regions mentioned above, especially Hale Passage, Henderson Bay and portions of Carr Inlet. Within 300 feet of shore railroad grades occur along 16.7 miles, following the entire shoreline from the eastern edge of the Nisqually delta, north to the Tacoma Narrows bridge and beyond.

The Lowland Nisqually River exhibits a branching and multiple channel pattern and over the last 130 years, frequent channel shifts have occurred (Collins et al, 2003). Large wood jams are a critical component to maintaining the anastomosing character of the lower Nisqually River. Patches of mature forests on the floodplain of the Nisqually River still exist and contributed to the "channel-switching dynamic" of this system (Collins et al, 2003). Field data collected in 1998 showed the Nisqually River contained approximately 8 times more wood per channel width than the Snohomish and 21 times more wood than the Stillaguamish, most of the difference "accounted for by the abundance of wood in jams in the Nisqually River" (Collins et al, 2003).

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface are found mostly along the eastern shore from Steilacoom, north (PSAT 2004).

In this sub-basin, toxic contaminants such as PCBs in the food chain are a concern, from both past and present activities. Sediment contaminant levels were compared from 1989-1996 to levels in 2000, and revealed that the most numerous increases in PAH levels occurred on East Anderson Island, compared to other sample locations (PSWQAT 2002a).

See Figure E-10.3 for information about the distribution of water quality impairments in this sub-basin.

Alteration of biological populations and communities

Pacific herring have been found to be "3 to 11 times more contaminated with PCBs in central and south Puget Sound than the Strait of Georgia" (WDFW, unpublished data). These WDFW results from 2004 are similar to those reported in 1999 and 2000 in PSWQAT (2002a), where body burdens of PCBs were higher in Pacific herring from the central basin (Port Orchard) and southern Puget Sound basin (Squaxin Pass) than Pacific herring from northern Puget Sound and the Strait of Georgia. Finally, the WDFW researchers report that the PCB-contaminated food web of Puget Sound may explain the source of the PCBs identified in southern resident killer whales. See the ecological section, above, for additional information.

There are approximately 13 hatcheries releasing various salmonids into this sub-basin, which may cause alteration of community structure, competition for available prey resources and predation of wild fish. There are several commercial shellfish aquaculture operations, mostly raising Pacific (Japanese) oyster, Manilla clams and various native species. Significant recreational fishing pressure may have changed the historic community structure of fish species throughout this sub-basin. Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine discharges via urbanization

We identified and analyzed 35 pocket estuaries for their level of function for juvenile Chinook. Urbanization is currently stressing 8 of those pocket estuaries. Days Island and Burley lagoon were determined to be not properly functioning for juvenile Chinook. See Figure E-10.4 for a list of pocket estuaries and an indication of the stressors noted through review of oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp are not found in this sub-basin. 15% of the shoreline (24 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for all four life history types of the Nisqually population emanating from this sub-basin,
b) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area,
c) Provide marine support for sub-adult and adult anadromous bull trout populations using the lower Nisqually as foraging, migration, and overwintering habitat,
d) Provide marine support for summer chum populations outside of the eight populations targeted for recovery (e.g., Hood Canal/Eastern Strait of Juan de Fuca)
e) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook, summer chum, and bull trout
f) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout whose natal streams are outside this sub-basin

a) Provide continued support for all neighboring Puget Sound populations, specifically significant non-natal Chinook salmon use of this sub-basin by fish primarily from the main basin (juveniles, sub-adults, and adults).

Realized function for listed salmon and bull trout

Fry migrant Chinook – Over two-thirds of the pocket estuaries within five miles of the Nisqually delta are estimated to be properly functioning (Figure E-10.2) and with minimal stressors noted (Figure E-10.4). Slightly over half the pocket estuaries between five and ten miles from the Nisqually delta are estimated to be properly functioning. Fry migrants emerging from the delta in search of the shallow water, low-velocity habitats associated with pocket estuaries will find fully functioning pocket estuaries nested within somewhat protected shorelines from the western edge of the delta, stretching toward Johnson Point, as well as across Nisqually Reach to include the southern half of Anderson Island. Pocket estuaries are nearly absent along the eastern shore as fry migrants emigrate northward. This region of shoreline exhibits armored shorelines with a continuous railroad grade along the shoreline, but with a relatively unpopulated shoreline region up to Steilacoom. Connectivity between habitat types and landscape classes, including intact freshwater “lenses” (or bands) along shorelines, is essential for small-sized fry migrants emerging from the Nisqually delta in search of rearing, refuge and osmoregulatory habitats within pocket estuaries. Any disruption such as habitat fragmentation or reduction/elimination of freshwater contribution in areas between the delta and destination pocket estuaries would be detrimental to this life history type.

Delta fry Chinook – The net loss of intertidal wetlands within the Nisqually delta from historic conditions was relatively low (0.61 mile^2 or 395 acres) (Bortleson et al., 1980). Consequently, the opportunity for delta fry to access delta habitat is presently realized, and this is improving each year (e.g., up to 1000 acres are slated for recovery by 2006). On average, delta fry are an abundant Chinook salmon life history type in Puget Sound, entering the estuarine environment at a small size, and utilizing the myriad estuarine habitats for rearing, osmoregulatory function and predator avoidance (refuge) until reaching a size (i.e., parr migrant or larger) where they venture out to the neritic and pelagic waters of Puget Sound. As with fry migrants, connectivity between habitat types and landscape classes is essential. Delta fry moving out of the delta environment (as larger fish) can access mostly protected shorelines and properly functioning pocket estuaries to the north and northwest of the Nisqually delta. As delta fry make their way to the northern reaches of this sub-basin, the fish are exposed to several wastewater discharges and chemicals. In addition, "resident" fish from this and other sub-basins (central Puget Sound and south Puget Sound) are experiencing higher toxic contaminant body burden levels versus those salmon migrating through these sub-basins from elsewhere (WDFW, unpublished data).

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. Parr migrants from the Nisqually Chinook salmon population, as well as populations from central Puget Sound, have access to pocket estuaries occurring at a rate of 1.35 per square mile throughout the sub-basin (>50% are estimated as properly functioning). Parr migrants from the Nisqually population spend anywhere from a week to a month or more in the estuary before moving out into the larger waters of the sub-basin, and beyond. Connectivity between habitat types and landscape classes is essential to this life history type. Parr migrants moving south out of the central Puget Sound sub-basin are thought to greatly utilize, and depend on the shoreline habitats within the Carr-Nisqually sub-basin. The shorelines of McNeil Island, Anderson Island and the terminus of Henderson Bay exhibit pocket estuaries either properly functioning or at risk, as well as relatively unarmored shorelines.

Yearling – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrants) within this sub-basin will negatively affect yearling migrants. Connectivity between habitat types and landscape classes is very important to yearlings from the Nisqually population, and other populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the other sections above. Yearling migrants can derive functions (e.g., foraging, refuge, migratory pathway) from available nearshore habitats as described above. Of concern are the toxic contaminants polluting the food web in the three southern sub-basins, and the body burden effects on salmon.

Sub-adult and adult Chinook - Larger fish migrating through this sub-basin must contend with water quality issues and toxic contaminants in the food chain. Researchers from WDFW have documented that, in general, Chinook salmon living in or migrating through Puget Sound (specifically in central and south sound) are more contaminated with PCBs than stocks outside of Puget Sound (e.g., Columbia River, WA coast). See Figure 4.7 in Section 4. Residence time in the central and southern Puget Sound basins is suspected as a "primary predictor of PCB concentration in Chinook salmon" and as such, those salmon spending the greatest amount of time in central and south sound exhibit the greatest PCB concentrations (WDFW, unpublished data) (Figure 4-8). Another toxic contaminant of concern in Puget Sound is PBDEs, a common chemical that, like PCBs, are found in greater concentrations in resident Chinook salmon versus migratory Chinook salmon.

Listed summer chum – We hypothesize that none of the eight populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU targeted for recovery use this sub-basin. However, those populations of summer chum listed in the Salmon Use section, above, do utilize this sub-basin.

Anadromous bull trout – Bull trout have not been observed in the Nisqually River in recent years and it is not known if a remnant population persists (USFWS 2004). However, it is believed that as populations recover, the lower Nisqually River and the McAllister Creek estuary will be important to bull trout in this region of Puget Sound (specifically proximate populations to the north), as foraging, migration, and overwintering habitat (USFWS 2004).

Table 6-20. Recommended protection actions for Carr/Nisqually

Protection action	**Benefit to Natal Chinook**	**Benefit to Other (non-natal) Chinook**	**Benefit to summer chum, bull trout, other fish**
Aggressive protect areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of the Nisqually delta	Sustained feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Sustained feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Sustained feeding, growth, refuge and migratory functions for other species
Protect against catastrophic events, especially any spills in the Narrows as this is a bottleneck region for migration.	Sustained growth and migratory functions	Sustained growth and migratory functions	Sustained growth and migratory functions for other species
Protect small tributary regions throughout the sub-basin	Sustained feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Sustained feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Sustained feeding, growth, refuge and migratory functions for other species
Protect functioning drift cells supporting eelgrass bands and depositional features along Anderson, McNeil, Ketron and Fox island shorelines and the Gig Harbor peninsula shoreline along the Narrows (Shoreline Protection Target Areas 3,4,8 and 9 in Figure E-10.5). Consider designating these shorelines for the highest level of protection within shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines and support landowner incentive programs for conservation.	Sustained feeding, growth, refuge and migratory functions	Sustained feeding, growth, refuge and migratory functions	Sustained feeding, growth, refuge and migratory functions for other species

Table 6-21. Recommended improvement actions for Carr/Nisqually

Improvement action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Add enhanced treatment for stormwater discharging directly to Puget Sound to the same standards as for salmon bearing streams.	Improved feeding, growth, osmoregulation and refuge, reduced mortality	Improved feeding and refuge	Improved feeding and refuge for other species
Consider wastewater reclamation and reuse retrofits for McNeil Island and Solo Point discharges.	Improved feeding, growth, osmoregulation and migratory functions, reduced mortality	Improved feeding and migratory functions	Improved feeding and migratory functions for other species
Aggressively promote shellfish environmental codes of practice.	Improved feeding, refuge and migratory functions	Improved feeding, refuge and migratory functions	Improved feeding, refuge and migratory functions
Aggressive restore areas, especially shallow water/low gradient habitats and pocket estuaries, within 5 miles of the Nisqually delta	Improved feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Improved feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Improved feeding, growth, refuge and migratory functions for other species
Continue to restore the Nisqually delta - up to 1000 acres should be restored within the next couple years	Improved feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Improved feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Improved feeding, growth, refuge and migratory functions for other species
Retrofit the railroad grade from the Nisqually River to Point Defiance to address access to blocked pocket estuaries. Remove the separation of upland and aquatic environments	Improved feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Improved feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Improved feeding, growth, refuge and migratory functions for other species
Increase the tidal prism of the Nisqually delta through dike removal and elevation of Interstate 5 across the freshwater tidal portions of the delta.	Improved feeding, growth, refuge, osmoregulation and migratory functions for Nisqually population	Improved feeding, growth, refuge and migratory functions for other populations, especially Main Basin populations	Improved feeding, growth, refuge and migratory functions for other species
Conduct limited beach nourishment on a periodic basis to mimic the natural sediment transport processes in select sections where corridor functions may be impaired (Shoreline Restoration Target Areas 1, 2,5, 6 and 7 in Fig. E-10.5).	Improved feeding, growth, refuge and migratory functions	Improved feeding, growth, refuge and migratory functions	Improved feeding, growth, refuge and migratory functions for other species
Encourage voluntary re-vegetation of cleared residential shorelines throughout the sub-basin.	Improved feeding, growth, refuge and migratory functions	Improved feeding, growth, refuge and migratory functions	Improved feeding, growth, refuge and migratory functions for other species

6.11 South Sound

A. Assessment

1. Salmon Use

Chinook

This is part of the Central and South Sound region, which includes six independent populations in the Cedar-Lake Washington, Green, Puyallup, and Nisqually river systems but none from the streams draining directly to this sub-basin.

a) Juvenile

- Juvenile Chinook salmon from non-natal populations, primarily fish from central Puget Sound and the Carr-Nisqually sub-basins, utilize the shorelines and pocket estuaries for feeding and growth, refuge, physiological transition and as a migratory corridor (juvenile salmon functions). See Figure 3-1 for a list of all Chinook populations. This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of juveniles of many populations from all five geographic regions of origin, but is likely most importantly for populations from the geographic region it lies within, and adjacent geographic regions of origin.

b) Adult

- Sub-adult and adult salmon from neighboring populations utilize habitats within this sub-basin as a passage corridor and grazing area. This sub-basin provides direct support to meeting the Chinook ESU criteria by supporting rearing of sub adults of many populations from all five geographic regions of origin, but is likely most importantly for populations from the geographic region it lies within, and adjacent geographic regions of origin.

Other Listed Species (not comprehensively reviewed or assessed for this sub-basin)

- Chum salmon: None of the eight populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU targeted for recovery emanate from or use this sub-basin. However, summer chum populations within the ESU are documented to exist in this sub-basin in Coulter Creek, Sherwood Creek, Deer Creek, Cranberry Creek, Johns Creek, and Rocky Creek.
- Bull trout (anadromous): Preliminary core populations within the Puget Sound Management Unit of bull trout do not exist in this sub-basin. It is not known if any anadromous bull trout use this sub-basin.

2. Ecological and Landscape Conditions

Food Web, Ecological Conditions

Portions of this sub-basin exhibit poor water quality, and if not addressed or corrected, may continue to negatively affect the ecology of this sub-basin. As in the Central Puget Sound and

Carr-Nisqually sub-basin, toxic contaminants such as PCBs and PBDEs (and others) are polluting the food web of Puget Sound, particularly the central and south sound basins (three sub-basins: central Puget Sound, Carr-Nisqually, south Puget Sound). Natal Chinook salmon populations from the two basins as well as a primary salmon prey (i.e., Pacific herring) appear to be contaminated with toxics (see following sections for more detail). These “resident” salmon (i.e., natal populations) exhibit greater concentrations of toxics when compared to migratory salmon (i.e., non-natal populations) passing through each sub-basin.

The Department of Natural Resources hypothesizes that because of the extreme tidal range of South Sound and the exacting physiological requirements of eelgrass, the species is effectively precluded from growing in this sub-basin naturally. At extreme low tides, eelgrass would be subject to dessication. At extreme high tides, light would not penetrate the water to a sufficient intensity to sustain eelgrass growth. (Tom Mumford, WADNR, personal communication) This hypothesis should receive further testing. What South Sound does have in abundance is mudflats. These habitats can exhibit extreme primary productivity through production of a diatom biofilm that grows on the mudflat surface. This bio-film is receiving considerable attention for its role in overall primary productivity in intertidal systems as well as its role in stabilizing fine sediments.

A comprehensive approach toward restoration of the historical water quantity, nutrients, and water quality baseline pathways and patterns will likely be necessary to protect and restore ecological functions to conditions supporting viable populations in protected sub-basins with limited circulation, such as the Carr-Nisqually, Hood Canal, Padilla sub-basins. Preventing further degradation of D.O. and other water quality factors including avoidance of further stormwater loadings and NPDES discharge loadings will be key. Beyond that, redirection of sewage treatment discharges to upland treatment and reuse/recharge systems will be needed to reduce summer time loadings that are degrading D.O. levels and shifting nearshore community structure. In South Sound the approach may need to address retrofitting of the existing sewage treatment facilities (e.g., LOTT, Shelton, etc.) and alternative approaches to future projects to reduce nutrient and contaminants loadings to the nearshore to improve D.O. and ecological functions supporting salmon. The same applies to existing and future stormwater treatment approaches (Bill Graeber, NOAA-TRT, pers. comm.).

Re-creation of the Deschutes River estuary represents a riverine estuary restoration potential of regional significance. Restoring the Deschutes River estuary represents one of only a few opportunities to recover an increment of the 70% historic loss of this habitat type in a block large enough to be a fully functional river estuary and to restore ecologic processes at the regional scale. In particular, based upon recent studies on pocket estuary utilization it appears the Deschutes River could serve a significant role in increasing the estuarine rearing potential for the Nisqually Chinook population which would serve to fill some of the ESU need for the life history diversity, spatial structure, productivity, and abundance that riverine estuaries can support (Bill Graeber, NOAA-TRT, pers. comm.)

Overall area

- Total area (deep-water plus nearshore) is 57,344 acres (89.6 square miles), the smallest of all 11 sub-basins
- Deep-water portion (marine waters landscape class) comprises 22,848 acres (35.7 square miles), or 40% of the total sub-basin area.

Nearshore area

- Nearshore portion comprises 34,496 acres (53.9 square miles), or 60% of the total sub-basin area.
- Nearshore area within this sub-basin is 8% of the nearshore area of the entire Puget Sound basin.
- Contains 293 miles of shoreline (beaches landscape class).
- The "key" bays (landscape class) identified in this sub-basin is Henderson Inlet, Budd Inlet, Eld Inlet, Totten Inlet, Oakland Bay, North Bay, Rocky Bay, and Vaughn Bay.
- Ninety linear miles (31%) of the shoreline is designated as marine riparian (defined as the estimated area of length overhanging the intertidal zone).
- In this sub-basin, 3% of the shoreline (10 linear miles) has eelgrass (*Zostera marina* and *Z. japonica*); may be patchy or continuous.
- In this sub-basin, floating kelp does not occur. In this sub-basin, 32% of the shoreline (93 linear miles) has non-floating kelp; may be patchy or continuous.

Landscape Conditions

See Figures E-10.1 through 10.3, E11.4 and E-11.5 for a presentation of some of the landscape conditions for this sub-basin

Pocket Estuary Analysis

We identified 62 pocket estuaries in this sub-basin. They are distributed relatively uniformly throughout the sub-basin, with the exception of only a couple in Hammersley Inlet and Oakland Bay, none in southern Budd Inlet, and none in Pickering Passage.

- Freshwater sources were observed in less than half of the pocket estuaries,
- Based on the assumptions listed in Appendix B, all three of the Chinook functions (feeding, osmoregulation and refuge) were estimated were estimated to occur in 20 of the 62 pocket estuaries. Most of the remaining pocket estuaries were estimated to have two of the three Chinook functions,
- Twenty-six pocket estuaries were estimated to be *properly functioning*. Thirteen pocket estuaries were estimated to be *not properly functioning*. The remaining pocket estuaries were recorded as *at risk*.

Drift Cell Analysis

A drift cell characterization for this sub-basin assessed the role of longshore sediment transport processes in controlling the structure of certain features along the shoreline that support salmon.

For example, the broad intertidal and subtidal shelves that provide shallow, vegetated patches and corridors along the shoreline are a depositional feature of soft sediments generally at the depositional portions of drift cells or at the intersection of longshore drift and deltaic processes. The methods of this analysis are presented in Appendix E, Figure E-11.5 and subsequent text. Recommendations for protection and restoration are highlighted in Tables 6-22 and 6-23.

Threats/stressors

Loss and/or simplification of delta and delta wetlands

Natal estuaries for Chinook salmon do not occur in this sub-basin. There are many other smaller estuaries and delta wetlands in this sub-basin, but no information are presented here.

Alteration of flows through major rivers

Large-scale flow alterations are present on the Deschutes River at Capitol Lake. Refer to the Ecological Section above for information. Smaller dams and diversions likely exist but are not identified here.

Modification of shorelines by armoring, overwater structures and loss of riparian vegetation/LWD

The projected population growth in Thurston and Mason counties between 2000-2025 is 62% (129,470 people) and 52% (25,683 people), respectively (PSAT 2004). In this sub-basin, shoreline armoring occurs along 109 miles (37%) of the shoreline. Over 55 miles of shoreline are classified as 100% armored. Over 147 miles are classified as 0% armored. The total number of overwater structures is 2,626, consisting of ramps (83), piers and docks (228), small slips (2,308) and large slips (7). Overwater structure such as ramps, piers and docks generally overlap with the shoreline armoring regions mentioned above, especially Budd Inlet, Eld Inlet, northern Case Inlet and North Bay and portions of Pickering Passage. Within 300 feet of shore railroad grades occur along 9.1 miles, near the western terminus of Oakland Bay in Shelton.

Contamination of nearshore and marine resources

Regions with 15% or greater impervious surface are concentrated in Olympia and Shelton (PSAT 2004). Sediment samples analyzed from 1997-1999 reveal that some of the greatest toxicity was found in the Port of Olympia based on a series of four toxicity tests designed to gauge impacts on biota (PSWQAT 2002a). In addition, the South Puget Sound region was one of four regions with the greatest degree of degraded sediments (PSWQAT 2002a). 8.2% of the area of South Sound exceeds the state's sediment quality standard and 5.5% of the area exceeds the cleanup screening levels.

Water quality concerns are discussed elsewhere in this evaluation. Ten sewage outfalls and an unknown number of stormwater discharge are also observed in this sub-basin.

Numerous past and present activities contribute to the contamination of nearshore and marine resources in this sub-basin and include, but are not limited to, wastewater discharges from industrial and municipal sources; stormwater discharges; and other hazardous substance spills. These are discussed in more detail in Section 4. In this sub-basin, toxic contaminants such as PCBs in the food chain are a concern. This is discussed in more detail in the realized function section, below.

Alteration of biological populations and communities

Pacific herring have been found to be "3 to 11 times more contaminated with PCBs in central and south Puget Sound than the Strait of Georgia" (WDFW, unpublished data). These WDFW results from 2004 are similar to those reported in 1999 and 2000 in PSWQAT (2002a), where body burdens of PCBs were higher in Pacific herring from the central basin (Port Orchard) and southern Puget Sound basin (Squaxin Pass) than Pacific herring from northern Puget Sound and the Strait of Georgia. Finally, the WDFW researchers report that the PCB-contaminated food web of Puget Sound may explain the source of the PCBs identified in southern resident killer whales. See the ecological section, above, for additional information.

There are approximately 6 hatcheries releasing various salmonids into this sub-basin, which may cause alteration of community structure, competition for available prey resources and predation of wild fish. In addition, the Squaxim Island Tribe maintains net pens for rearing coho salmon in Percival Cove, a part of the Budd Inlet/Deschutes estuary system. There are extensive commercial and recreational shellfish aquaculture operations, mostly raising Pacific (Japanese) oyster, Manilla clams and various native species, especially in Henderson Inlet, Eld Inlet, Totten Inlet, Oakland Bay and Hammersly Inlet systems. Significant recreational fishing pressure may have changed the historic community structure of fish species throughout this sub-basin. Specific hatchery reform recommendations for this region have been formulated by the Hatchery Scientific Review Group available at the following websites.
http://www.lltk.org/pdf/HSRG_Recommendations_February_2002.pdf
http://www.lltk.org/pdf/HSRG_Recommendations_March_2003.pdf

Transformation of land cover and hydrologic function of small marine drainages via urbanization

South Sound has more pocket estuaries than any other sub-basin in Puget Sound based on our analysis and only 8 are stressed with urbanization at this time. See Figure E-11.4 for a list of pocket estuaries and noted stressors from visual observation via oblique aerial photos.

Transformation of habitat types and features via colonization by invasive plants

Spartina spp is not found in this sub-basin. Also, 17% of the shoreline (50 miles) contains *Sargassum muticum*, which may be patchy or continuous.

B. Evaluation

In this section we list goals and evaluate the level of realized function for natal and non-natal Chinook, summer chum, and bull trout. From this we then list each of the proposed protection and restoration actions for this sub-basin, and describe the benefits to natal Chinook, non-natal Chinook, and summer chum and bull trout (if any).

Goals for listed salmon and bull trout whose natal streams are in this sub-basin

a) Provide early marine support for independent spawning aggregations occurring in this sub-basin.

Goals for listed salmon and bull trout how natal streams are outside this sub-basin

b) Provide support for all neighboring Puget Sound Chinook salmon populations from the main basin (e.g., Chinook salmon from the central Puget Sound and Carr-Nisqually sub-basins).
c) Provide support for sub-adult and adult Chinook salmon populations who utilize habitats within this sub-basin as a migratory corridor and grazing area,
d) Maintain and/or increase forage fish production as prey for neighboring salmon populations
e) Provide for connectivity of habitats; also, adequate prey resources, marine foraging areas, and migratory corridors for juvenile, sub-adult and adult Chinook and summer chum for populations from within the main basin (e.g., central Puget Sound sub-basin).

Realized function for listed salmon and bull trout

Fry migrant Chinook – Although South Sound has no natal estuary for an independent population of Chinook and little eelgrass due to its naturally large tide range, 60 percent of the area of the sub-basin is in the nearshore and it has a higher density of pocket estuaries than most other sub-basins (Figure E-10.2). The opportunity exists for fry migrants to derive function from the shallow water, low velocity habitats, but is limited mostly to a few regions within five and 10 miles of the Nisqually estuary (e.g., several pocket estuaries along the west shoreline of Anderson Island, southern Key peninsula and Thurston County shoreline southeast of Johnson Point). These pocket estuaries are nested within mostly protected shorelines and are available and utilized by the non-natal fry migrants from the Nisqually population. A majority of these proximate pocket estuaries are estimated to be properly functioning, providing juvenile salmon functions such as feeding and growth, refuge, areas of physiological transition.

Connectivity between habitat types and landscape classes, including intact freshwater "lenses" (or bands) along shorelines, is essential for small-sized fry migrants emerging from the Nisqually estuary in search of pocket estuaries in the south sound sub-basin. Any disruption such as habitat fragmentation or reduction/elimination of freshwater contribution in areas between the estuary and destination pocket estuaries would be detrimental to the non-natal fry migrants. For example, the reduction or loss of freshwater "seeps" along shorelines due to the loss/reduction of groundwater recharge because of stormwater re-routing to the sound via pipes may prevent fry migrants from reaching pocket estuaries. This activity could jeopardize the fry migrant life history type.

Delta fry Chinook – As a matter of proximity, the opportunity exists for delta fry from the Nisqually population to derive function (rearing, osmoregulatory function, migratory corridor and predator avoidance (refuge)) from the protected shoreline habitats of this sub-basin. On average, delta fry are an abundant Chinook salmon life history type in Puget Sound. As with fry migrants, connectivity between habitat types and landscape classes is essential, and shallow water, low velocity regions are very important. Delta fry moving out of the non-natal Nisqually estuary environment (as larger fish) can access pocket estuaries to the northwest (Case Inlet region) as well as several inlets to the west. Just over one-third of the sub-basin's shorelines are armored, but as delta fry grow to larger sizes and migrate throughout this sub-basin more frequently, the fish are exposed to many regions with wastewater discharges, an increasing occurrence of low dissolved oxygen (Budd Inlet, Case Inlet), elevated water temperatures (Budd Inlet) and a concentrated region of chemical pollution (Budd Inlet) (Figure F-3). In addition, "resident" fish from this and other sub-basins (central Puget Sound and Carr-Nisqually Inlet) are experiencing higher toxic contaminant body burden levels versus those salmon migrating through these sub-basins from elsewhere (WDFW, unpublished data). Finally, the current level of shoreline development places the unique character of this sub-basin and associated functions for salmon at risk.

Parr migrant Chinook – Many of the Puget Sound Chinook salmon migrate to the ocean as sub-yearlings (Myers et. al., 1998), and on average this life history type is the most abundant in Puget Sound. The opportunity exists for parr migrants from the non-natal Nisqually population to utilize shoreline habitats within this sub-basin, and connectivity between habitat types and landscape classes is essential to this life history type. Parr migrants moving northwest out of the Carr-Nisqually sub-basin are thought to greatly utilize, and depend on many of the shoreline habitats within the South Sound sub-basin. As larger juveniles make their way through the region, they will encounter *properly functioning* pocket estuaries clustered near Squaxin Island and Totten Inlet, and *at risk* and *not properly functioning* pocket estuaries spread throughout the remaining sub-basin (except for most of Budd Inlet where none are identified). Parr migrants will encounter heavily armored shorelines in Budd Inlet, Eld Inlet, Hammersley Inlet and portions of Case Inlet, as well as the other stressors described above. The toxic contaminant situation described above also presents a problem for this life history type. As mentioned above, the current level of shoreline development places the unique character of this sub-basin and associated functions for salmon at risk.

Yearling Chinook – Any reduction in capacity as a result of non-support of the other life history types (i.e., primarily parr migrants) within this sub-basin will negatively affect yearling migrants. Yearlings emigrating from the non-natal Nisqually population, as well as from other populations around Puget Sound, can derive some function (e.g., foraging, refuge, migratory pathway) from the many pocket estuaries and stretches of protected shorelines. Other regions of this sub-basin require attention and some restoration activities (e.g., Budd Inlet). Connectivity between habitat types and landscape classes in South Sound is very important to yearlings from all non-natal populations moving about broadly within Puget Sound. Yearling migrants will be exposed to the same types of stressors and ramifications as described in the other sections above. Of concern are the toxic contaminants polluting the food web in the three southern sub-basins, and the body burden effects on salmon.

Sub-adult and adult Chinook - Larger fish migrating through this sub-basin must contend with water quality issues and toxic contaminants in the food chain. Researchers from WDFW have documented that, in general, Chinook salmon living in or migrating through Puget Sound (specifically in central and south sound) are more contaminated with PCBs than stocks outside of Puget Sound (e.g., Columbia River, WA coast). See Figure 4.7 in Section 4. Residence time in the central and southern Puget Sound basins is suspected as a "primary predictor of PCB concentration in Chinook salmon" and as such, those salmon spending the greatest amount of time in central and south sound exhibit the greatest PCB concentrations (WDFW, unpublished data) (Figure 4-8). Another toxic contaminant of concern in Puget Sound is PBDEs, a common chemical that, like PCBs, are found in greater concentrations in resident Chinook salmon versus migratory Chinook salmon.

Listed summer chum – We hypothesize that none of the eight populations of the Hood Canal/Eastern Strait of Juan de Fuca Summer Chum ESU targeted for recovery use this sub-basin.

Anadromous bull trout – We hypothesize that bull trout do not use this sub-basin.

Table 6-22. Recommended protection actions for South Sound

Protection action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Protect against water quality degradation		Sustained growth and migratory functions	Sustained growth and migratory functions for other species
Protect pocket estuaries in the eastern third of the sub-basin to support the Nisqually population (west shoreline of Anderson Island, southern Key peninsula and Thurston County shoreline southeast of Johnson Point).		Sustained feeding, growth, refuge and migratory functions for other populations, especially Nisqually population	Sustained feeding, growth, refuge and migratory functions for other species
Aggressively protect functioning drift cells that support depositional features throughout the sub-basin but in particular along the west shoreline of Key peninsula, Hartstene Island, east shoreline of Budd Inlet, all of Totten and Skookum inlets, Oakland Bay and outer Hammersly Inlet (Shoreline Protection Target Areas 4, 6, 7, 9and 12 in Fig. E-11.5). Designate these shorelines for the highest level of protection within shoreline master programs and critical areas ordinances and pass strong policies limiting increased armoring of these shorelines.		Sustained feeding, growth, refuge and migratory functions	Sustained feeding, growth, refuge and migratory functions for other species
Protect small freshwater tributary		Sustained feeding,	Sustained feeding, growth,

regions, especially those that support mudflat structure through deltaic processes (Upland Sediment Source Protection Targets 1,2,3, 13 and 14 in Fig. E-11.5)		growth, refuge and migratory functions for other populations, especially Nisqually population	refuge and migratory functions for other species
Protect against catastrophic events		Sustained growth and migratory functions	Sustained growth and migratory functions for other species

Table 6-23. Recommended improvement actions for South Sound

Improvement action	Benefit to Natal Chinook	Benefit to Other (non-natal) Chinook	Benefit to summer chum, bull trout, other fish
Add enhanced treatment for stormwater discharging directly to Puget Sound to the same standards as for salmon bearing streams		Improved growth and migratory functions	Improved growth and migratory functions for other species
Consider wastewater reclamation and reuse retrofits for LOTT and Shelton wastewater discharges		Improved growth and migratory functions	Improved growth and migratory functions for other species
Aggressively promote shellfish environmental codes of practice		Improved feeding, refuge and migratory functions	Improved feeding, refuge and migratory functions
Encourage voluntary re-vegetation of cleared residential shorelines throughout the sub-basin		Improved feeding, growth, refuge and migratory functions	Improved feeding, growth, refuge and migratory functions for other species
Restore tidal influence to the historic Deschutes estuary (Capital Lake)		Sustained feeding, growth, refuge and migratory functions for other populations, especially Nisqually population	Sustained feeding, growth, refuge and migratory functions for other species
Restore pocket estuaries in the eastern third of the sub-basin to support the Nisqually population (west shoreline of Anderson Island, southern Key peninsula and Thurston County shoreline southeast of Johnson Point).		Sustained feeding, growth, refuge and migratory functions for other populations, especially Nisqually populations	Sustained feeding, growth, refuge and migratory functions for other species